NPS-56-80-008

NAVAL POSTGRADUATE SCHOOL

Monterey, California

COMBAT DAMAGE ASSESSMENT TEAM

A-10/GAU-8 LOW ANGLE FIRINGS
VERSUS
SIMULATED SOVIET TANK COMPANY (ARRAY 22)
(LAVP Lot Number AJD 79A181-001, AEROJET)

(7 NOVEMBER 1979)

R.H.S. STOLFI
R.R. McEACHIN

JUNE 1980

FEDDOCS
D 208.14/2:NPS-56-80-008

ved for public release; distribution unlimited.

red for: A-10 System Program Office
Wright Patterson Air Force Base
Ohio 45433

NAVAL POSTGRADUATE SCHOOL
Monterey, California

Rear Admiral J. J. Ekelund
Superintendent

Jack R. Borsting
Provost

The work reported herein was supported by the A-10 System Program Office, Wright Patterson Air Force Base, Ohio. The reproduction of all or part of this report is authorized.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Date Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NPS-56-80-008

2. GOVT ACCESSION NO.:

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE *(and Subtitle)*: A-10/GAU-8 Low Angle Firing versus Simulated Soviet Tank Company (Array 22) (7 November 1979) LAVP Lot Number AJD 79A181-001, Aerojet

5. TYPE OF REPORT & PERIOD COVERED: Special report for Array Firings of 7 November 1979

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): R.H.S. Stolfi, R.R. McEachin

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Naval Postgraduate School, Monterey, California 93940

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:

11. CONTROLLING OFFICE NAME AND ADDRESS: A-10 System Program Office, Wright-Patterson Air Force Base, Ohio 45433

12. REPORT DATE: June 1980

13. NUMBER OF PAGES:

14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*:

15. SECURITY CLASS. *(of this report)*: Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

1. automatic cannon ammunition
2. GAU-8 cannon
3. A-10 aircraft
4. main battle tank (MBT)
5. Lot Acceptance Verification Program (LAVP)
6. empirical firing tests
7. combat stowed targets
8. gun ammunition lethality
9. MBT vulnerability & survivability

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report describes firings of the A-10/GAU-9 weapon system on 7 November 1979 against a Soviet tank company simulated by 10 combat loaded M-47 tanks. The pilot making the firing passes attacked at low altitude and used correspondingly low dive angles in order to simulate movement through a hostile air defense system. Ammunition used in the attacks comprised Aerojet Lot Number AJD 79A181-001 30mm armor piercing incendiary (API) rounds, which (continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE S/N 0102-014-6601

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

(block 20 continued)
proved to be effective damage agents against substantial areas of the U.S. MK 47 tanks used as targets. The pilot in ten successful firing passes fired a total of 174 rounds of which 90 impacted the targets. Of the projectiles impacting on targets 30 achieved perforations of the armored envelope. Significant results include catastrophic damage to 3 tanks, 1 tank immobilized and silenced, three tanks immobilized only.

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	1
Attack Parameters	1
Weapon Effects	1
Damage Assessment	1
Test Conditions	2
Results	2
BACKGROUND	4
TEST PHILOSOPHY	4
SIMULATED GROUND COMBAT SITUATION	6
TARGET TANKS	7
TEST PERFORMANCE AND RESULTS	7
DAMAGE ASSESSMENT	15
Tank Number 7	16
Tank Number 28	18
Tank Number 49	20
Tank Number 41	22
Tank Number 47	24
Tank Number 30	26
Tank Number 48	28
Tank Number 33	30
Tank Number 38	32
Tank Number 39	34
SUMMARY AND CONCLUSIONS	37
APPENDIX A	39
APPENDIX B	44

LIST OF FIGURES

Figure		Page
1.	Russian T-62 Medium Tank	8
2.	U.S.A.F./Fairchild Republic A-10 Aircraft	10
3.	Fairchild A-10 Series Aircraft	11
4.	GAU-8/A 30mm Gun System	12
5.	30mm Armor Piercing Incendiary (API) Round	13
6.	Approximate Target Layout	14
7.	Impact Diagram, Tank 7	17
8.	Impact Diagram, Tank 28	19
9.	Impact Diagram, Tank 49	21
10.	Impact Diagram, Tank 41	23
11.	Impact Diagram, Tank 47	25
12.	Impact Diagram, Tank 30	27
13.	Impact Diagram, Tank 48	29
14.	Impact Diagram, Tank 33	31
15.	Impact Diagram, Tank 38	33
16.	Impact Diagram, Tank 39, Right Side	35
17.	Impact Diagram, Tank 39, Front	36
A-1.	Array 22 Attack Aspect Summary	43

LIST OF TABLES

Table		Page
I.	Array 22 Summary of A-10 Aircraft in Low Dive Angle Gun Attack Versus Simulated Soviet Tank Company . .	3
II.	Comparison of Ideal and Practical Test Situations .	5
A-I.	Array 22 Results Summary	40
A-II.	Array 22 Perforation Location Summary	41
A-III.	Array 22 Aircraft Attack Parameters	42

COMBAT DAMAGE ASSESSMENT COMMITTEE (CDAC) EXECUTIVE SUMMARY

Under the technical direction of the Combat Damage Assessment Committee (CDAC), the Combat Damage Assessment Team (CDAT) conducted firings of the A-10/GAU-8 weapon system against an array of 10 tanks simulating a Soviet tank company deployed for an attack. The CDAT used M-47 tanks stowed with main gun ammunition, diesel fuel, lubricating oil, and crew manikins to simulate the Soviet tanks. The pilot of the A-10 aircraft used in the firings conducted firings at low altitudes and low dive angles which simulated attack below the altitude of effective engagement for opposing air defense networks employing acquisition and fire control radar. The purpose of the test was to evaluate the effects of the 30mm API anti-tank ammunition (Aerojet Lot Number AJD 79A181-001) for the GAU-8 gun under challenging conditions of engagement for the A-10/GAU-8 system against realistically simulated Soviet main battle tanks.

The CDAC assessed the results of the low angle cannon firings of the A-10 aircraft against the simulated Soviet tank company as follows:

1. Attack Parameters: The pilot of the A-10 aircraft attacked the simulated Soviet tank company at low altitude and dive angles. The GAU-8 cannon has a cockpit selectable nominal fire rate of either 4200 rounds per minute or 2100 rounds per minute. The system was set to fire at the 2100 round per minute rate during this test. The pilot made a total of 10 passes, each at a primary tank target. The passes resulted in projectile impacts on 10 primary target tanks. The attack dive angles averaged 3.8 degrees for the ten passes against the targets. Open-fire slant range averaged 2470 feet. The pilot fired 174 rounds in ten bursts averaging 17.4 rounds and 0.57 seconds each.

2. Weapons Effects: The A-10/GAU-8 weapon system achieved 90 impacts on the 10 tank targets. The ratio of direct impacts to total rounds fired was a substantial 0.49. Ricochet impacts are also capable of causing damage. If the ricochet impacts are added to the direct impacts, the overall ratio of impacts to rounds fired becomes 0.52. The weapon system achieved 30 perforations of the armored envelopes of the tanks with a ratio of perforations to total impacts of 0.33. The ratio of perforations to direct impacts is 0.35. Many projectiles, which did not perforate armor, severely damaged exterior track and suspension components of the tanks as well as gun tubes.

3. Damage Assessment: The attacking A-10/GAU-8 weapon system inflicted three catastrophic kills on tanks in the company array. Four more tanks were immobilized, of which two were deprived of, or seriously degraded in, the use of main armament. Two more tanks sustained such light damage that there was no significant degradation to either mobility or fire-power. Another tank suffered a minor degradation in mobility and fire-power. The Simulated Soviet Tank company was judged to have been effectively neutralized and incapable of continued offensive action, since all

tanks except three were immobilized.

4. Test Conditions: The target tanks were sited in open, flat desert terrain with no cover and little concealment. Aerial weather conditions were ones of unlimited ceiling and visibility. Shortly after the initial firing, clouds of white dust from projectile impacts were evident. Such conditions effectively simulated the actual obscuration which would have been presented to the pilots in combat.

5. Results: The overall results of the test are summarized in Table I.

TABLE I. Array 22 Summary of A-10 Aircraft in Low Angle Gun Attack versus Simulated Soviet Tank Company (7 November 1979)

Tank No.	A-10 Primary Pass*	APPROACH		ATTACK		GUN EFFECTS			DAMAGE			Tank Immob-ilized ?	Tank Aspect (Degrees)
		Speed (FPS)	Alt (Feet)	Open Fire Range (Feet)	Dive Angle (Degrees)	Rounds (Each)	Impacts (Each)	Perfs (Each)	M %	F %	K %		
7	1/1	579	473	2699	-3.0	26	6	0	-	-	-		078
28	1/2	559	438	2191	-4.0	16	12	4	100	-	-	Yes	105
49	1/3	561	463	2334	-5.0	18	3	0	-	-	-		110
41	1/4	564	453	2406	-4.0	14	11	6	100	95	-	Yes	078
47	1/5	569	413	2334	-3.0	12	5	3	-	-	100	Yes	088
30	1/6	571	393	2263	-3.0	11	8	6	-	-	100	Yes	075
48	1/7	573	393	2547	-3.0	15	9	4	100	100	-	Yes	078
33	1/8	566	583	2758	-6.0	19	8	2	100	-	-	Yes	097
38	1/9	567	413	2547	-3.0	16	12	0	5	10	-		082
39	1/10	569	463	2618	-4.0	27	16	5	-	-	100	Yes	070
Applicable Totals:						174	90	30				7	
Averages:		568	449	2470	-3.8	17.4	9.0	3.0					
									3 K-Kills 1 M- & F-Kill 3 M-Kills 1 minor M & F degradation				Right Side

* 1/1 means pilot 1, pass 1; 1/2 means pilot 1, pass 2, etc.

BACKGROUND

Since February, 1978, the Armament Directorate, A-10 System Program Office, Wright Patterson Air Force Base, Ohio, has conducted firing tests using the A-10/GAU-8 system in low-level, air-to-ground engagements of armored targets. The tests have been conducted within the framework of the GAU-8 30mm ammunition Lot Acceptance Verification Program (LAVP) - Airborne. The LAVP has the following objectives which apply to the present tests:

A. To evaluate the performance of existing production lots of GAU-8 ammunition when fired from the air under operational conditions.

B. To evaluate the lethality of GAU-8 ammunition against armored targets when fired at low level from A-10 aircraft using operational tactics.

To conduct the LAVP program, the Armament Directorate has cooperated with Headquarters, Tactical Air Command, Langley AFB, Virginia and, in turn, with the Tactical Fighter Weapons Center, Nellis AFB, Nevada. Within the framework of that cooperation, the Armament Directorate has set up a Combat Damage Assessment Team (CDAT) to plan and execute the firing tests and evaluate the results. The CDAT functions under the direction of a Combat Damage Assessment Committee (CDAC) which has prepared this report of the firing test of 7 November, 1979.

TEST PHILOSOPHY

To generate realistic data, the CDAC determined to use a highly empirical technique of destructive testing of actual tank targets. Tests have involved firings at individual tanks in November, 1977 and February - March, 1978, and, more recently, arrays of vehicles in tactical formations. The experimental setup for the firings of 7 November, 1979 involved the use of a multi-target, tactically arrayed tank formation for attack by the A-10/GAU-8 system. The CDAT elected to simulate a Soviet tank company, as organized within a tank division, as the target array for the attacking A-10 aircraft. As few constraints as possible were placed on the attacking pilot in an attempt to develop as much realism as possible. Table II shows the test factors which would have been ideal in the test of 7 November, 1979 and the practicable setup which was achieved.

Table II. Comparison of Ideal & Practical Test Situations

Ideal Test Parameters	Practical Test Parameter
1. Air Attack Realism	1. Air Attack Realism
a. Actual A-10/GAU-8	a. Actual A-10/GAU-8
b. 30mm API	b. 30mm API
c. European Weather & Terrain	c. Nevada Weather & Desert Terrain
d. Optimum open-fire ranges (2000 ft)	d. Average open-fire range (2470 ft)
e. Low Altitude attack angle (< 6 degrees)	e. Low Altitude attack angle (< 6 degrees)
2. Air Defense Realism	2. Air Defense Realism
a. Automatic cannon firing at aircraft	a. Low-altitude, low-angle, minimum-exposure attacks versus assumed AD system
b. Missile systems firing at aircraft	b. Low-altitude, low-angle, minimum-exposure attacks versus assumed AD system
c. Small arms firing at aircraft	c. Low-altitude, low-angle, minimum-exposure attacks versus assumed AD system
d. AD suppression by aircraft	d. No suppression simulation in test
3. Threat Targets and Doctrine	3. Threat Targets and Doctrine
a. T62/T64/T72 high fidelity targets	a. Simulated Soviet Tanks
b. Stowed combat loads (in T62/T64/T72)	b. Stowed combat loads (in US M-47)
c. Realistic crew station postures	c. Wooden crew manikins
d. Dynamic combat formation	d. Static combat formation
e. Maneuvering evasive targets	e. Stationary targets

SIMULATED GROUND COMBAT SITUATION

The firing test of 7 November, 1979 simulated the attack by an A-10 aircraft on a Soviet tank company. The CDAC hypothesized the Soviet tank company to be the lead march security detachment for its battalion, which in turn, is the advance guard of a larger mobile formation. The lead detachment operates approximately five kilometers in front of the Soviet battalion column. The mission of the advance company is to ensure the uninterrupted advance of the battalion and provide security against attack. Upon meeting heavy resistance, the company deploys into an appropriate combat formation to reduce the resistance, or form a base of fire for offensive action by the remainder of the battalion.

A Soviet tank company, would probably have other units attached to it for its support. Attached units might include any one or all of the following elements: (1) motorized rifle platoon; (2) engineer detachment; (3) chemical defense specialists; (4) 122mm howitzer battery; (5) air defense element. The company simulated in the firing test consisted of tanks alone. The pure tank formation was arranged with two platoons up and one back, simulating an assault posture. The tanks used in the firing test were US M-47 tanks, largely intact, containing crew manikins, and stowed with ammunition, fuel, and oil. The tanks were not maneuvered during the firing test and the formation remained essentially a snapshot of the company at a single point in time.

TARGET TANKS

The most effective targets available in sufficient numbers to simulate Soviet T-55 and T-62 (Figure 1) tanks were the US M-47 tanks. Both of the Soviet tank models are similar in armor protection to the M-47. With the appropriate purging of the gasoline fuel system of the US tanks, the CDAT managed to field a target similar in survivability to the T-55 and T-62 tanks from the viewpoint of ignitable internal material. Few data are available on the Soviet T-64 and later model tanks from the viewpoints of armor protection and the arrangement of internal components. The decision was made, accordingly, to simulate the earlier model Soviet tanks with the readily available US tanks.

The M-47 tanks used for targets were in excellent condition from the viewpoint of damage assessment. The exterior components were complete and the tanks have proven to be effective targets for the collection of exterior mobility damage. Interior components were less complete in the target tanks. All of the most essential items were present, e.g., main gun, engine, transmission, fuel tanks, ammunition racks, etc., but other items such as oil coolers, range finders, vision devices, and radios, have not been present in all tanks.

The most sensitive internal items from the viewpoint of catastrophic kills and high percentage M- and F-Kills are the following, which were placed in the test tanks as noted:

Generic Sensitive Item	Test Item
1. Ammunition	US Cartridge, 90-mm TP-T
2. Fuel	Number 2 Diesel
3. Oil	Oil in Engine, Transmission and Drive Components.
4. Personnel	Articulated Plywood Manikins

The tanks were static during the test and their engines were not running, with the result that the fuel and oil were much cooler and more inert than would have been the case with a moving tank or a static vehicle with its engine running. The kill ratio achieved in the firing test of 7 November, 1979, therefore, is probably conservative from the viewpoint of fires resulting from ignited fuel and oil.

TEST PERFORMANCE AND RESULTS

Conduct of the test consisted of bringing together the ammunition, gun, aircraft, pilots, and combat arrayed and loaded tanks into a several minutes simulation of combat. In essence, the

FIGURE 1. Russian T62 Medium Tank

decisive elements which were fed into the test immediately prior to the firing were the following:

1. Aerojet Lot Number AJD 79A181-001 30mm API ammunition.
2. General Electric GAU-8 Gatling gun.
3. Fairchild Republic A-10 attack aircraft.
4. Fighter Pilot, 66th FWS, Nellis AFB.
5. US Designed M-47 main battle tanks, combat loaded.

The combat simulation itself comprised the aerial fire and maneuver of the attacking A-10 aircraft. A realistic way of presenting the combat simulation is to outline the sequence of pertinent events in each firing pass. These events and the pertinent data which the CDAT attempted to collect, in order to reconstruct the simulated combat firing of 7 November, 1979, were as follows:

Sequence	Event	Data
1.	Aircraft Approach	Speed, Altitude
2.	Aircraft Attack	Open-Fire Range, Dive Angle
3.	Aircraft Attack	Burst Time, Rounds Fired
4.	Aircraft Attack	Cease-Fire Range, Dive Angle
5.	Gun Effects, (Accuracy)	Impacts on Tanks
6.	Gun Effects, (Lethality)	Perforations through armor
7.	Tank Damage	Catastrophic (K-Kill), Mobility (M-Kill and Firepower (F-Kill) Kills

The data noted immediately above were collected through the combined efforts of the CDAT and range support personnel at Nellis AFB. Aerojet Ordnance Manufacturing Company personnel provided the industrial efforts required to repair, refurbish, and field the tank targets. The CDAT applied various systematic research techniques used to describe weapon effects and combat damage. The most basic materiel used in the test; i.e., the aircraft, gun, and projectile are illustrated in Figures 2, 3, 4, and 5. The targets were arrayed in the tactical formation of a Soviet tank company as shown in Figure 6.

The pilot making the attack flew from the base area and employed operational tactics immediately before and during the firing passes. The pilot approached the target area at low altitude and simulated target acquisition with the help of a forward air controller. The pilot then proceeded to attack the entire tank company and acquired targets at low altitudes and dive angles, simulating operation below the altitudes for effective acquisition and engagement by opposing air defense missile and gun systems.

FIGURE 2. U.S.A.F./Fairchild Republic A-10 Aircraft.

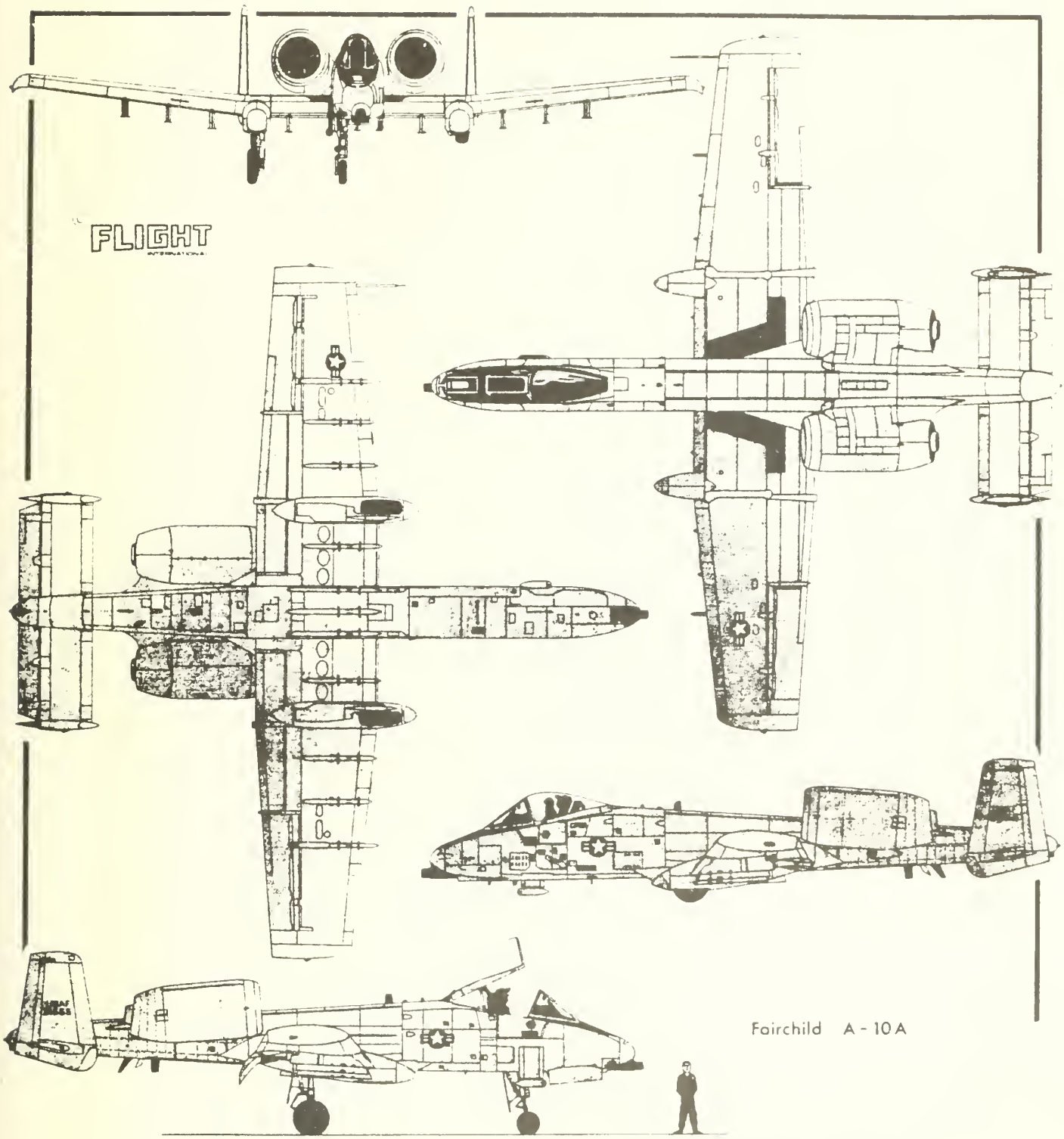


FIGURE 3. Fairchild A-10 Series Aircraft.

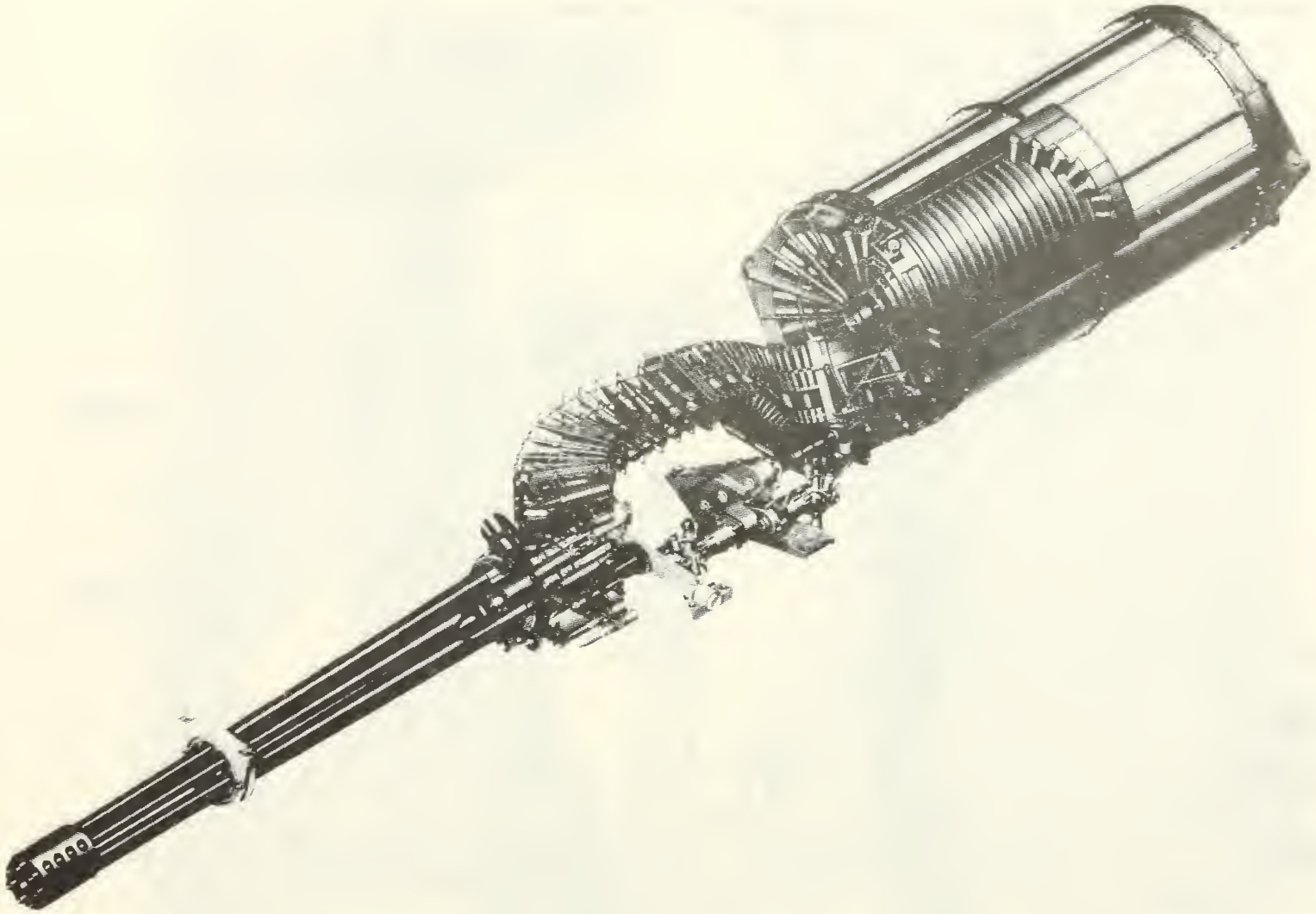


FIGURE 4. GAU-8/A 30mm Gun System

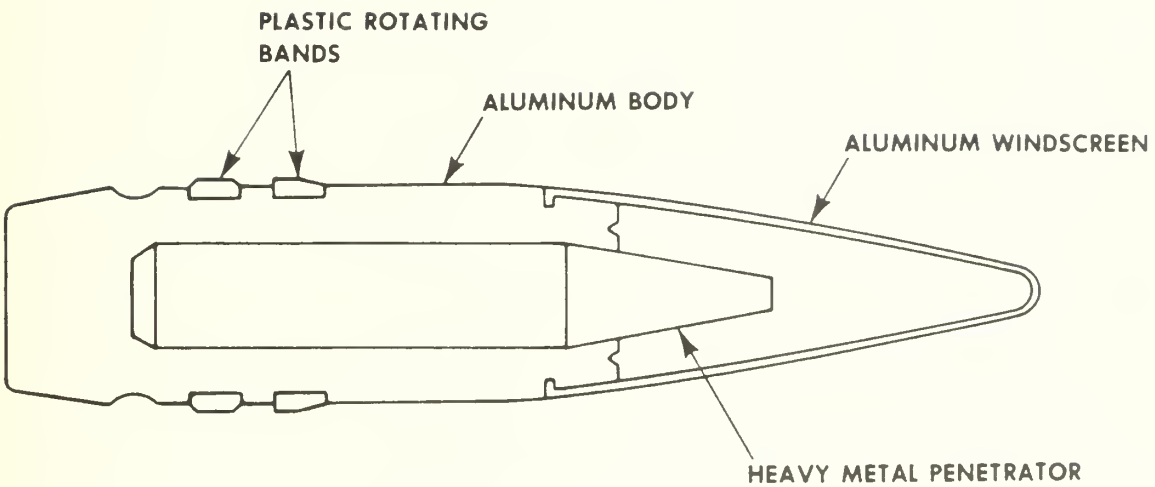


FIGURE 5. 30mm Armor Piercing Incendiary (API) Projectile

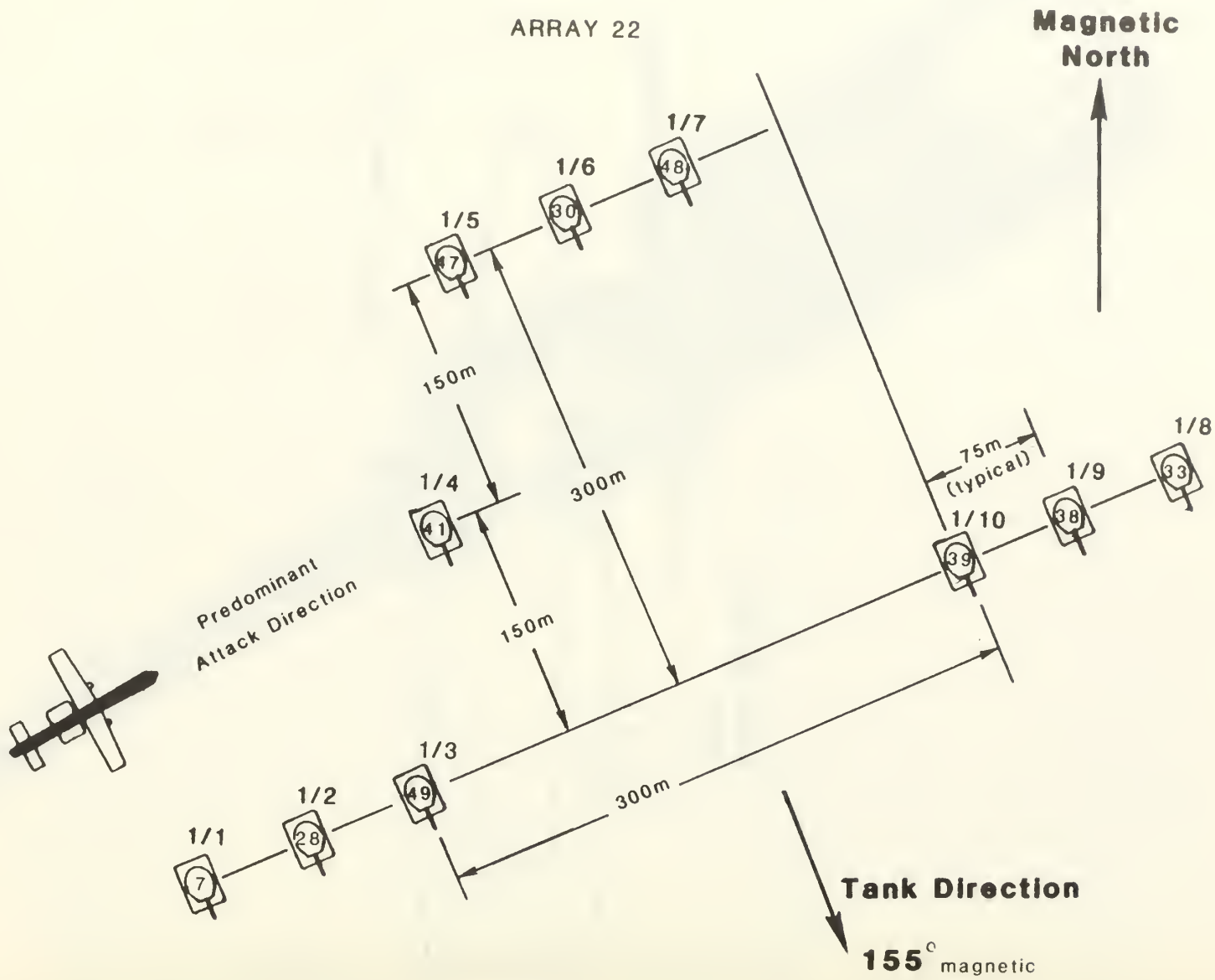


FIGURE 6. Approximate Target Layout.

DAMAGE ASSESSMENT

The damage assessment conducted by the CDAT is presented on the following pages. Appendix A contains graphical and tabular information relative to the mission in general plus summaries of the damage assessment for easy reference.

Terms used in the damage assessment summaries are defined in Appendix B.

Impacts on the tanks were arbitrarily numbered for identification purposes. The impacts were number sequentially, first at the turret level, then at the hull level. If additional impacts were discovered during the combat damage assessment (as was sometimes the case) they were given the next sequential number; i.e. no attempt was made to "correct" the sequence. THE READER IS CAUTIONED THAT THIS NUMBERING SYSTEM HAS NO RELATIONSHIP WHATSOEVER TO THE ARRIVAL SEQUENCE OF PROJECTILES ON THE TANK OR TO THE PORTION OF THE BURST IMPACTING THE TANK.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 7

1. Description:

The attacking A-10 aircraft achieved impacts on the tank from an attack aspect of 078 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 26 rounds during the firing pass.

2. Kill Assessment:

No degradation in mobility or firepower.

a.	Perforations	:	0
b.	Significant Impacts	:	0
c.	Insignificant Impacts	:	6
	TOTAL IMPACTS	:	6 (Figure 7)

3. Rationale for Kill Assessment:

No significant damage was inflicted on this target during the test.

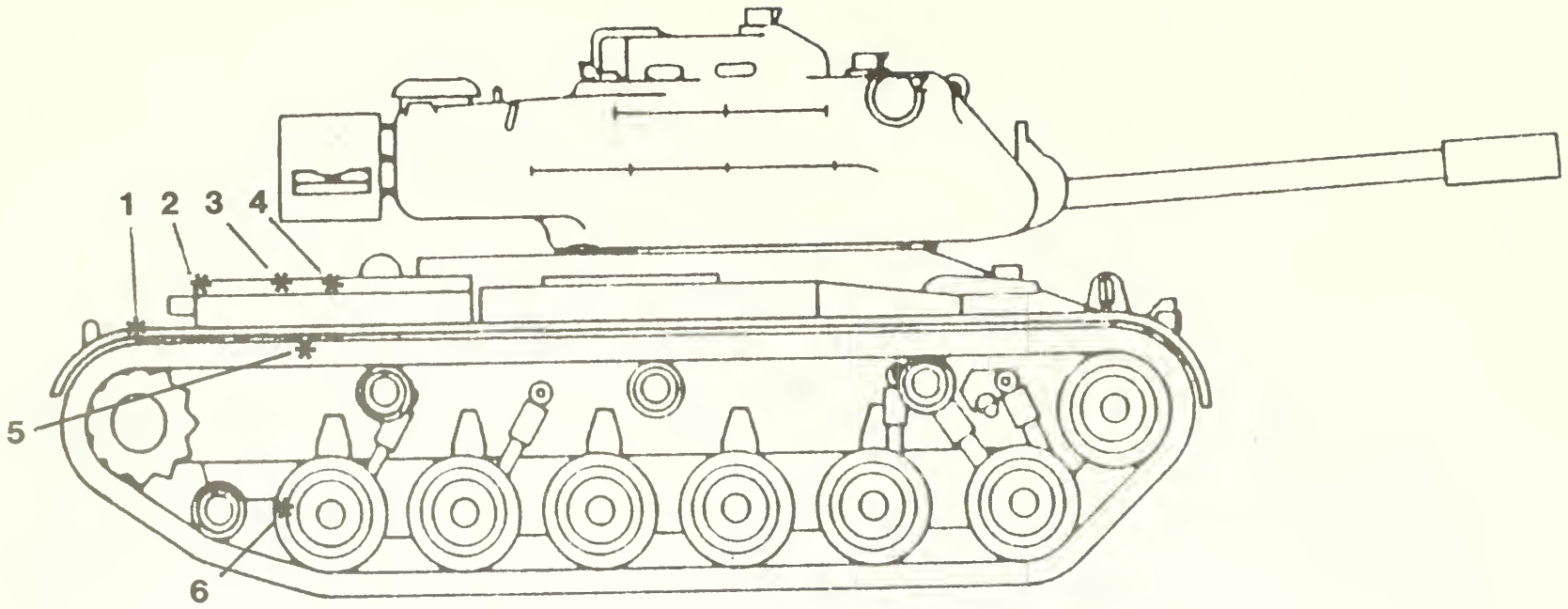


FIGURE 7. Impact Diagram, Tank 7.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 28

1. Description

The attacking A-10 aircraft achieved impacts on the tank from an attack aspect of 105 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 16 rounds during the firing pass.

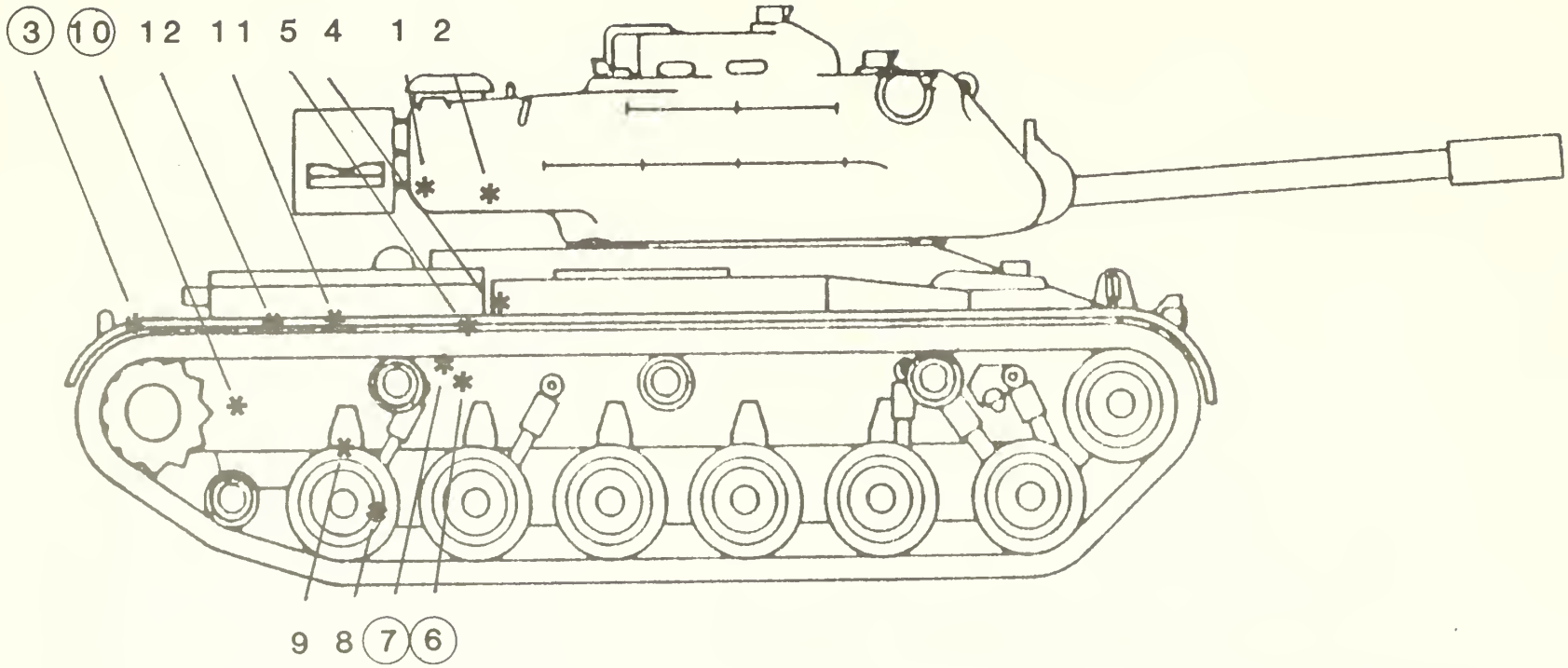
2. Kill Assessment:

100% M-Kill resulting from the following observed effects (Figure 8):

a.	Perforations	: 4
b.	Significant Impacts	: 2
c.	Insignificant Impacts	: 6
	TOTAL IMPACTS	: 12

3. Rationale for Kill Assessment:

The assessment of 100% M-Kill is based on impact 10, which perforated the engine compartment, penetrating the engine block causing loss of engine oil. Three other perforations and two hits contributed little or nothing to the kill.



LEGEND: Circled numbers indicate perforating impacts.

FIGURE 8. Impact Diagram, Tank 28.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 49

1. Description:

The attacking A-10 aircraft achieved impacts on the tank from an attack aspect of 110 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 18 rounds during the firing pass.

2. Kill Assessment:

No degradation to mobility or firepower.

a.	Perforations	:	0
b.	Significant Impacts	:	0
c.	Insignificant Impacts	:	3
	TOTAL IMPACTS	:	3 (Figure 9)

3. Rationale for Kill Assessment:

No significant damage was inflicted on the target tank during the tests.

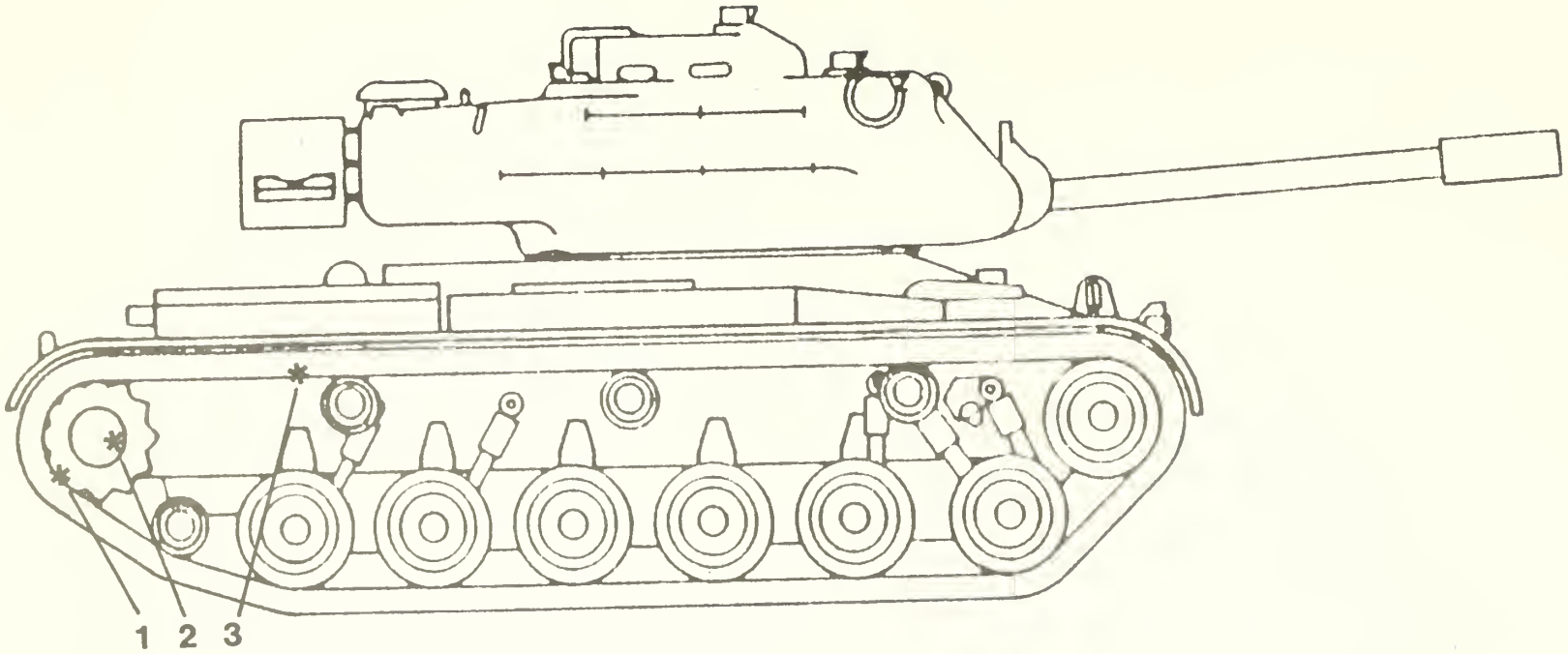


FIGURE 9. Impact Diagram, Tank 49.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 41

1. Description:

The attacking A-10 aircraft achieved impacts on the tank from an attack aspect of 078 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 14 rounds during the firing pass.

2. Kill Assessment:

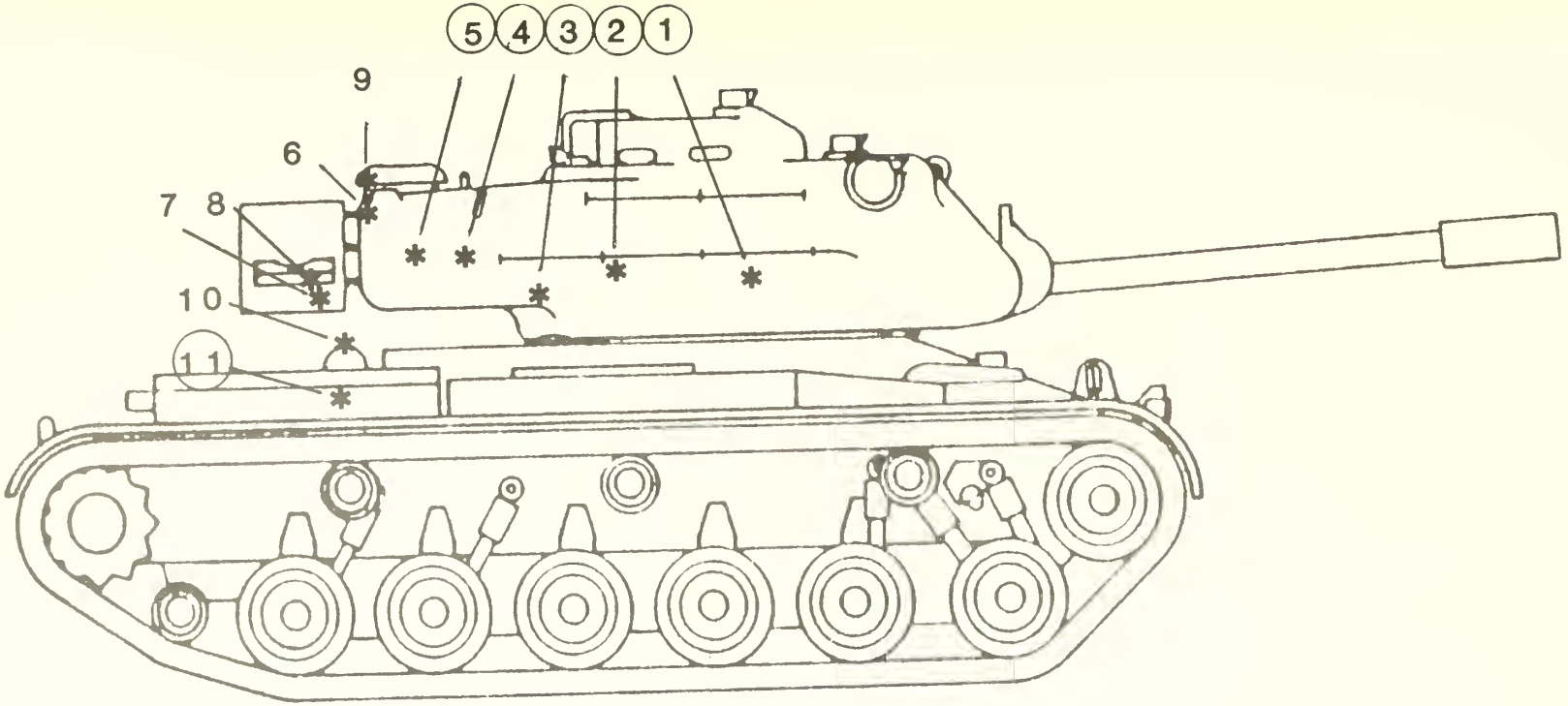
100% M-Kill and 95% F-Kill resulting from the following observed effects (Figure 10):

a.	Perforations	: 6
b.	Significant Impacts	: 0
c.	Insignificant Impacts	: 5
	TOTAL IMPACTS	: 11

3. Rationale for Kill Assessment:

a. M-Kill: The assessment of 100% M-Kill is based on impact 11, which perforated the right side of the hull into the engine compartment severing an oil cooler line and penetrating one engine valve cover.

b. F-Kill: The assessment of a 95% F-Kill is based on impacts 1, 2, and 3 which perforated the right turret armor and caused casualties to the commander, gunner, and loader. Two other perforations of the turret caused damage to interior components but contributed nothing to the F-Kill.



LEGEND: Circled numbers indicate perforating impacts.

FIGURE 10. Impact Diagram, Tank 41.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 47

1. Description:

The attacking A-10 aircraft achieved impacts on the tank from an attack aspect of 088 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 12 rounds during the firing pass.

2. Kill Assessment:

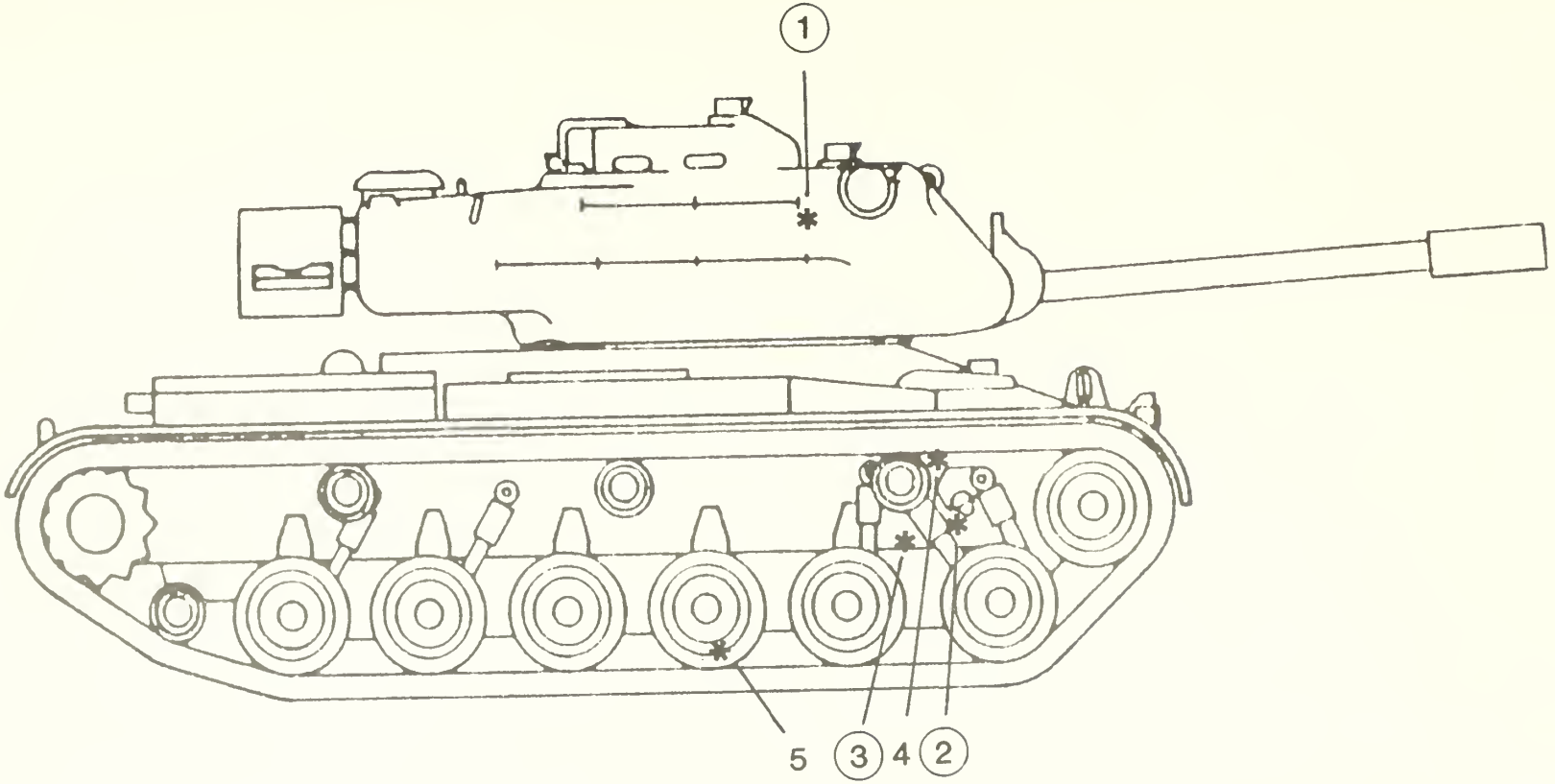
Catastrophic K-Kill resulting from the following observed effects (Figure 11):

a.	Perforations	: 3
b.	Significant Impacts	: **
c.	Insignificant Impacts	: **
	TOTAL IMPACTS	: 5

**Omitted - catastrophic fire and explosion overrode other damage.

3. Rationale for Kill Assessment:

A 100% K-Kill was assessed based on 1 perforation into the turret and 2 perforations into the driver's compartment. The tank was observed to be smoking immediatlely after the attack pass and in flames shortly thereafter, but the cause of the fire could not be determined.



LEGEND: Circled numbers indicate perforating impacts.

FIGURE 11. Impact Diagram, Tank 47.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 30

1. Description:

The attacking A-10 aircraft achieved impacts on the tank from an attack aspect of 075 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 11 rounds during the firing pass.

2. Kill Assessment:

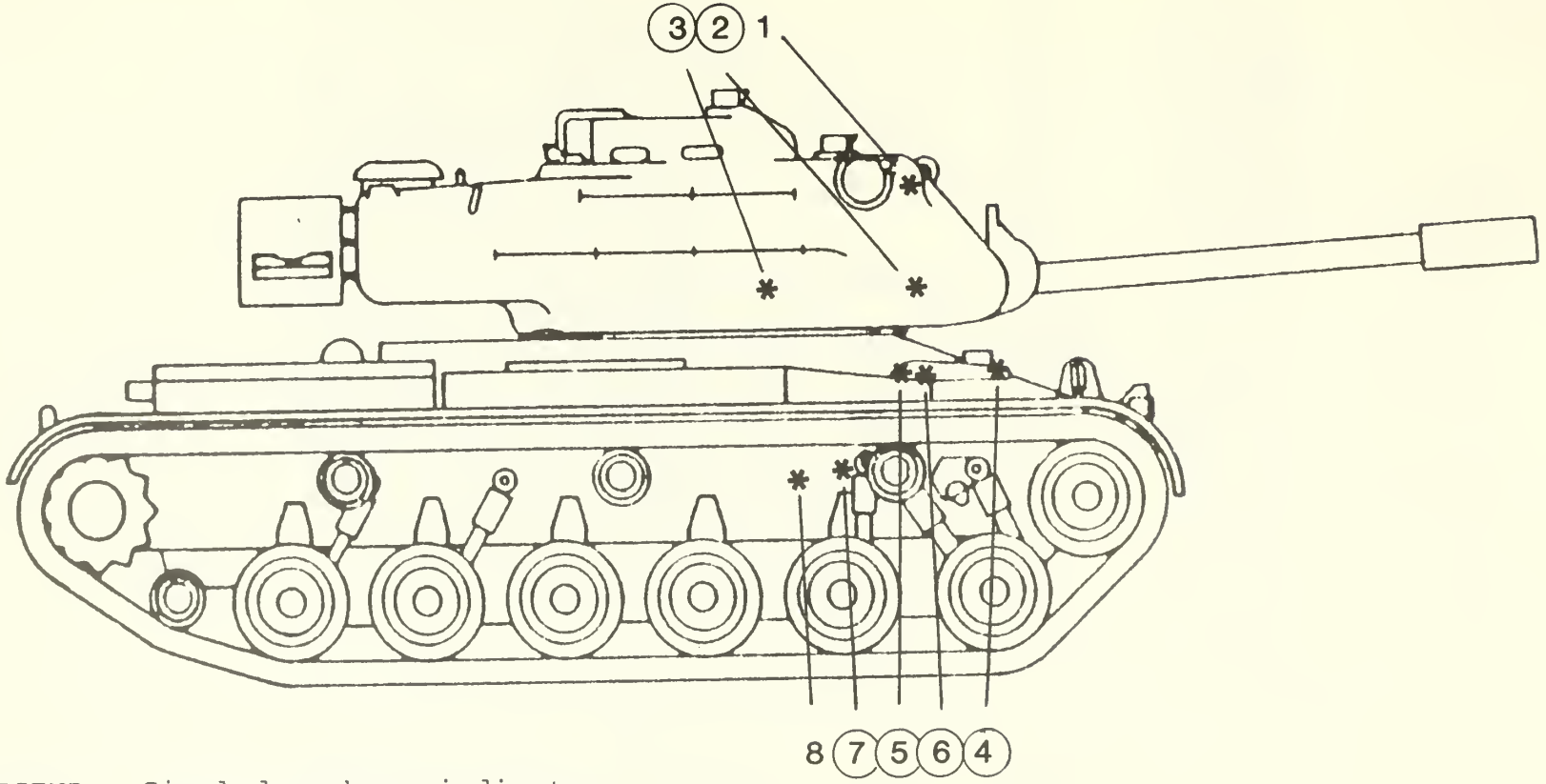
Catastrophic K-Kill resulting from the following observed effects (Figure 12):

a. Perforations	:	6
b. Significant Impacts	:	**
c. Insignificant Impacts:		**
TOTAL IMPACTS	:	8

**Omitted - catastrophic fire and explosion overrode other damage.

3. Rationale for Kill Assessment:

This tank was observed to explode immediately after the attack. Impact 7, which perforated the right hull armor and penetrated the ammunition stowage area, probably caused the explosion. Impact 6 also perforated the hull and could have impacted stowed ammunltion as well.



LEGEND: Circled numbers indicate perforating impacts.

FIGURE 12. Impact Diagram, Tank 30.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 48

1. Description:

The attacking A-10 aircraft achieved impacts on the tank from an attack aspect of 078 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 15 rounds during the firing pass.

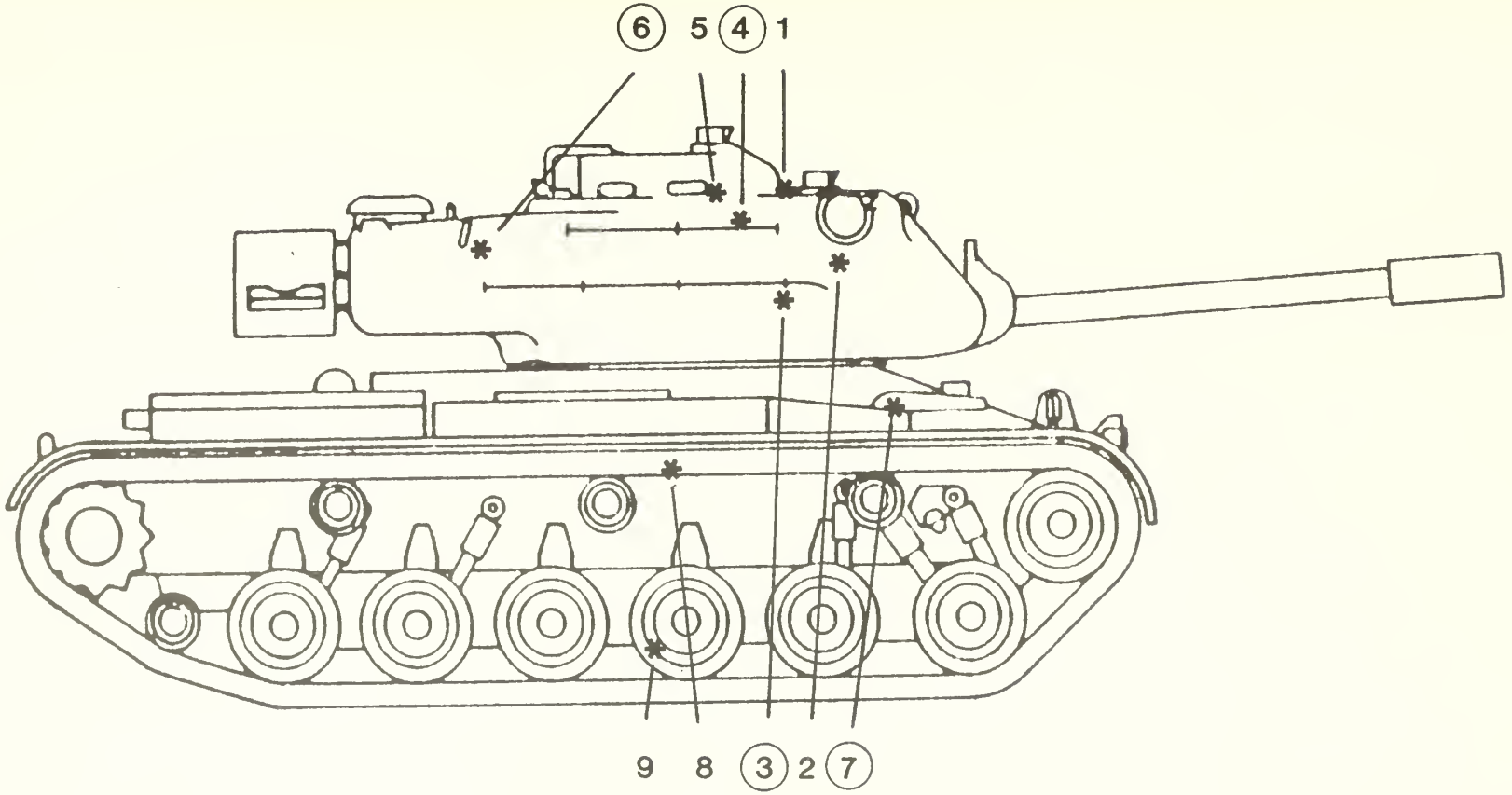
2. Kill Assessment:

100% M-Kill and 100% F-Kill resulting from the following observed effects (Figure 13):

a.	Perforations	: 4
b.	Significant Impacts	: 1
c.	Insignificant Impacts	: 4
	TOTAL IMPACTS	: 9

3. Rationale for Kill Assessment:

This was a delayed burn occassioned by an explosion and fire occurring a considerable length of time (an estimated 45 minutes) after the A-10 attack, and which damaged only the fighting and driver compartments. There was no evidence of fuel or ammunition fires directly resulting from perforations of the armored envelope. Impacts 3, 4, and 7 were perforations of the hull and turret at locations that could have resulted in casualties to all crewmen. Therefore a 100% M-Kill and a 100% F-Kill was assessed based on a presumption of crew casualties, and the fire was attributed to a cook-off caused by ignition of innocuous materiel such as wooden manikins or crash padding.



LEGEND: Circled numbers indicate perforating impacts.

FIGURE 13. Impact Diagram, Tank 48.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 33

1. Description:

The attacking A-10 aircraft achieved impacts on the tank from an attack aspect of 097 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 19 rounds during the firing pass.

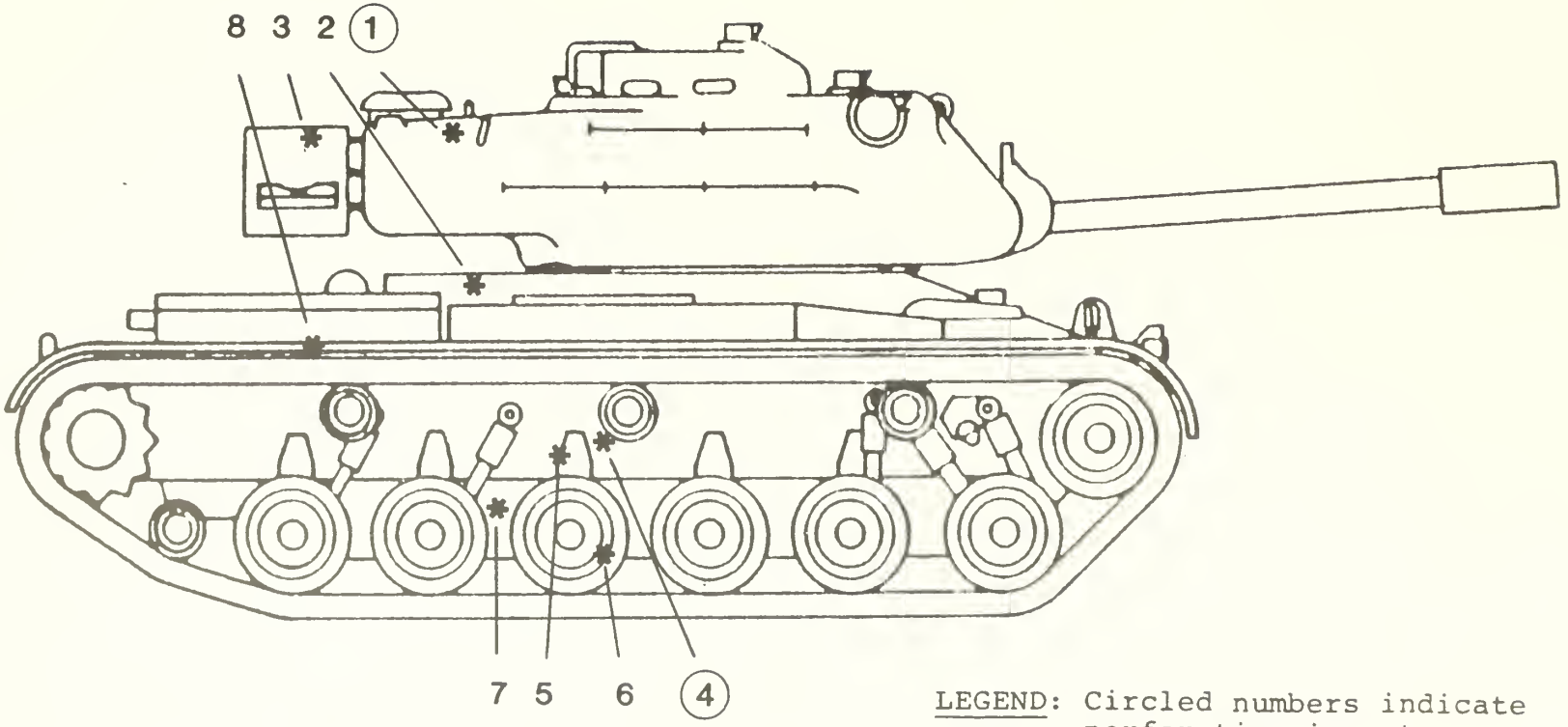
2. Kill Assessment:

100% M-Kill resulting from the following observed effects (Figure 14):

a.	Perforations	: 2
b.	Significant Impacts	: 0
c.	Insignificant Impacts	: 6
	TOTAL IMPACTS	: 8

3. Rationale for Kill Assessment:

The assessment of 100% M-Kill is based on impact 4 which perforated the right side of the hull, penetrating the fuel tank, causing loss of fuel.



LEGEND: Circled numbers indicate perforating impacts.

FIGURE 14. Impact Diagram, Tank 33.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 38

1. Description:

The attacking A-10 aircraft achieved impacts on the tank from an attack aspect of 082 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 16 rounds during the firing pass.

2. Kill Assessment:

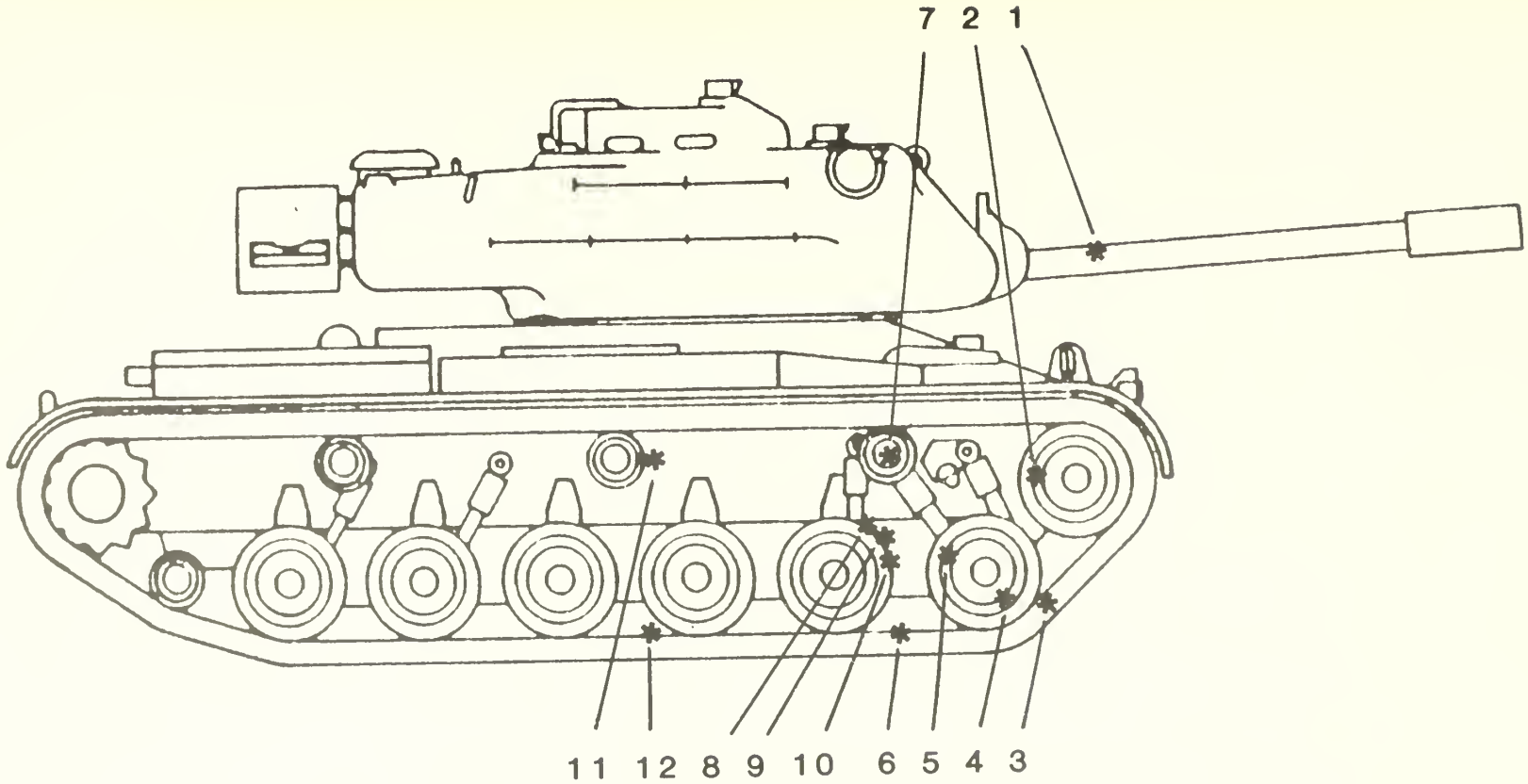
5% M-Kill and 10% F-Kill resulting from the following observed effects (Figure 15):

a.	Perforations	: 0
b.	Significant Impacts	: 6
c.	Insignificant Impacts	: 6
	TOTAL IMPACTS	: 12

3. Rationale for Kill Assessment:

a. M-Kill: The assessment of 5% M-Kill is based on minor cummulative damage to track and suspension system caused by impacts 2, 5, 6, 7, and 12.

b. F-Kill: The assessment of 10% F-Kill is based on damage caused by impact 1 which perforated one wall of the gun tube.



NOTES:

a. Hits #8 & #9 are behind #2 Road Wheel
b. Hit #10 is on Inboard #2 Road Wheel
c. Hit #11 is on Inboard Middle Track Support Roller

FIGURE 15. Impact Diagram, Tank 38.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 39

1. Description:

The attacking A-10 aircraft achieved impacts on the tank from an attack aspect of 070 degrees (right side) during one firing pass at low altitude and low dive angle. The A-10 expended 27 rounds during the firing pass.

2. Kill Assessment:

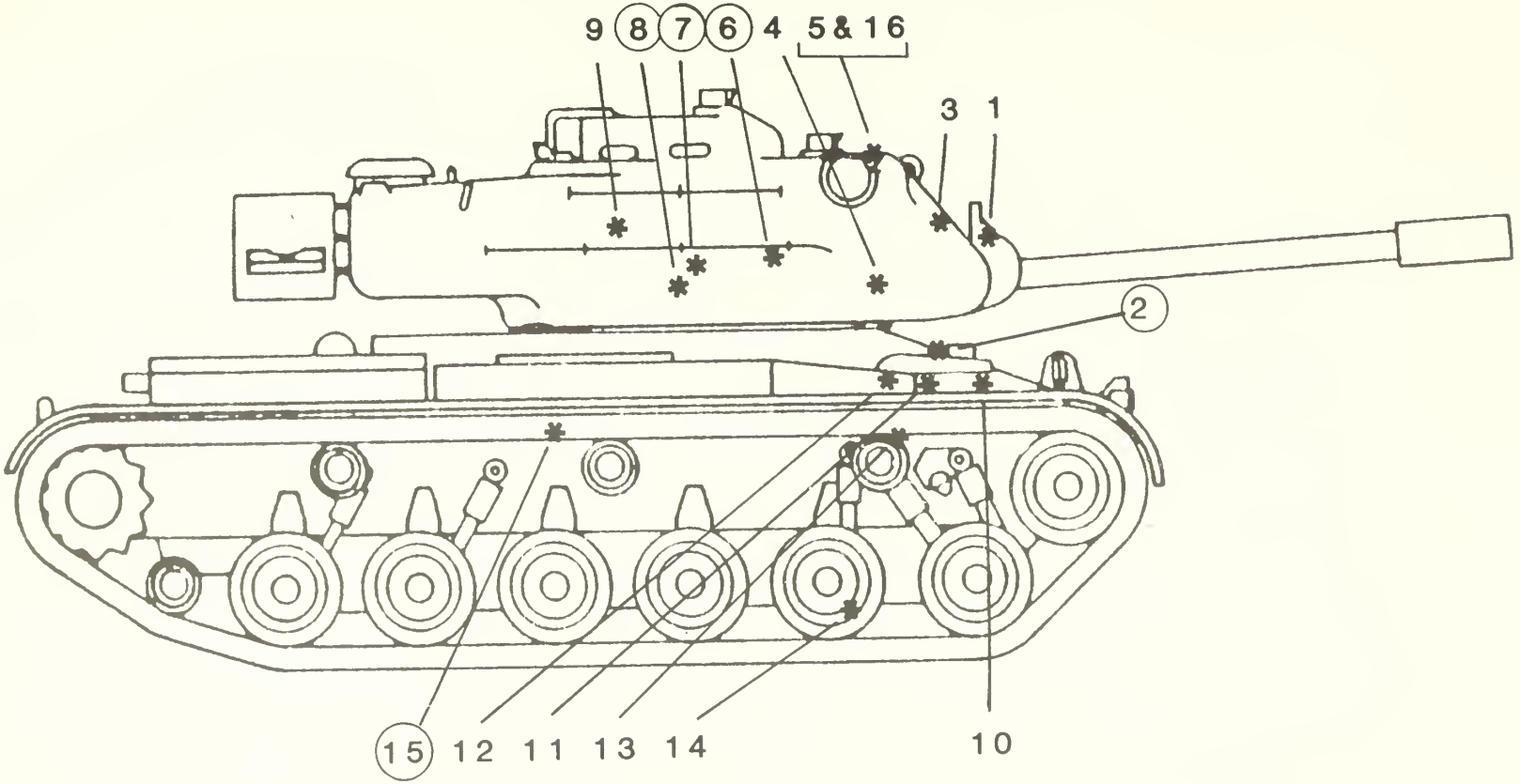
Catastrophic K-Kill resulting from the following observed effects (Figure 16 and 17):

a.	Perforations	: 5
b.	Significant Impacts	: **
c.	Insignificant Impacts	: **
	TOTAL IMPACTS	: 16

**Omitted - catastrophic fire and explosion overrode other damage.

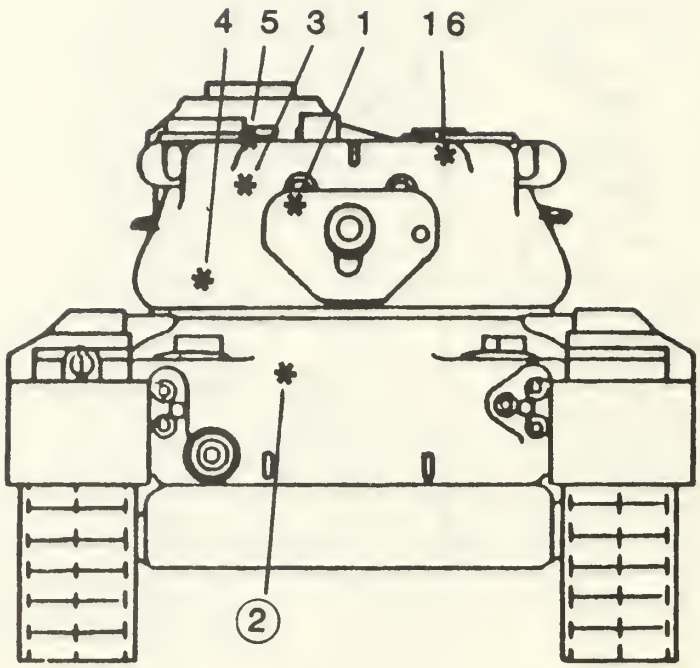
3. Rationale for Kill Assessment:

100% K-Kill resulting from impact 15 which perforated the right hull armor and penetrated the fuel tank causing a fire which could not be extinguished by the crew because of casualties inflicted by perforations 6, 7, and 8 which penetrated into the fighting compartment and perforation 2 which penetrated into the driver's compartment.



LEGEND: Circled numbers indicate perforating impacts.

FIGURE 16. Impact Diagram, Tank 39 Right Side.



LEGEND: Circled numbers indicate perforating impacts.

FIGURE 17. Impact Diagram, Tank 39 Front.

SUMMARY AND CONCLUSIONS

On 7 November, 1979, at Nellis AFB, Nevada, the Combat Damage Assessment Team (CDAT) conducted firings of the A-10/GAU-8 weapon system against an array of 10 tanks simulating a Soviet tank company deployed for an attack. The purpose of the firing test was to evaluate the effects of the 30mm API antitank ammunition of the GAU-8 gun under challenging conditions of engagement for the A-10/GAU-8 system against realistically simulated Soviet tank formations. The CDAT used M-47 tanks stowed with main gun ammunition, diesel fuel, lubricating oil, and crew manikins to simulate the Soviet tanks. The pilot of the A-10 aircraft used in the firings conducted his attacks at low altitudes and low dive angles which simulated attack below the altitude of the effective engagement for opposing air defense systems using acquisition and fire control radar.

The firing test can be summarized in terms of the following data which were collected and/or extracted from the firings:

Aircraft Parameters

1. Open-fire speed (average)-------- 568 ft/sec
2. Dive Angle (average)------------- 3.8 degrees
3. Open-fire Slant Range (average)-- 2470 ft
4. Burst Length/Rounds (averages)--- .57 sec/17.4 rds.
5. Number Passes (primary)---------- 10
6. Target Aspects (predominantly)--- Right Side

Weapon Effects		Target Damage	
1. Rounds Fired----------	174	1. K-Kills-------	3
2. Impacts---------------	90	2. M+F-Kills-----	1
3. Ricochets (off grnd)--	4	3. M-Kill--------	3
4. Direct Impacts--------	86	4. F-Kill--------	0
5. Perforation-----------	30	5. Light Damage--	3

These data and the more detailed base from which they were extracted can be arranged into measures of effectiveness for the A-10/GAU-8 system under conditions similar to those in the firing test, i.e., empirical combat simulation. The following values of effectiveness are based on the firing test on 7 November, 1979:

Measures of Effectiveness

Accuracy Related Ratio:		Lethality Related Ratio:	
$\frac{\text{Total Impacts}}{\text{Rounds Fired}}$	= 0.52	$\frac{\text{Perforations}}{\text{Total Impacts}}$	= 0.33
$\frac{\text{Direct Impacts}}{\text{Rounds Fired}}$	= 0.49	$\frac{\text{Perforations}}{\text{Direct Impacts}}$	= 0.35

Weapon System Effectiveness Ratio:

$\frac{\text{Tanks Immobilized}}{\text{Passes}}$	= 0.70	$\frac{\text{Tanks K-Killed}}{\text{Passes}}$	= 0.33

The ten target tanks were attacked predominately from the right side and suffered the severe damage shown in Table I and Table A-I.

The data and measures summarized above, and the other data contained in this report, support several inferences or conclusions:

1. The A-10/GAU-8 system in realistic simulation of combat is capable of inflicting catastrophic K-Kills as well as M- and F-Kills on M-47 and similarly protected main battle tanks, e.g., Soviet T-55 and T-62 tanks.

2. The weapon system in low level attacks can perforate specifically the side surfaces of the hulls and turrets of M-47 and similarly protected main battle tanks.

3. The weapon system is an effective killing agent against the side surfaces of M-47 and similar tanks when firing moderate length bursts of 0.40-0.85 seconds, containing 11-27 rounds.

4. From the viewpoint of GAU-8 30mm API ammunition effects and resulting damage to combat stowed main battle tanks, the tactic of low level attack in this firing test was shown to be a succesful one.

APPENDIX A

Graphical and Summary Information

Table A-I contains a summary of the results of mission 22 of 7 November, 1979. Table A-II relates the assessment of damages in Table A-I to locations of perforations. Table A-III summarizes the Aircraft Attack Parameters Altitude, Attitude, Airspeed, Firing Slant Range and Burst length for each pass on each target. Figure A-1 relates aircraft attack aspect by tank number to burst length in feet.

Table A-I. Array 22 Mission Results Summary
(7 November 1980)

Target Tank No.	Damage Assessment (M%)	(F%)	(K%)	All Target Impacts	Direct Impacts	Rounds Fired	Total Perforations
7	---	---	---	6	4	26	0
28	100	---	---	12	11	16	4
49	---	---	---	3	3	18	0
41	100	95	---	11	11	14	6
47	---	---	100	5	5	12	3
30	---	---	100	8	8	11	6
48	100	100	---	9	9	15	4
33	100	---	---	8	8	19	2
38	5	10	---	12	11	16	0
39	---	---	100	16	16	27	5
	TOTALS:			90	86	174	30

K = Catastrophic Kill; M = Mobility Kill; F = Firepower Kill

Table A-II. Array 22 Perforation Location Summary
(7 November 1979)

Target Tank	Damage Assessment* (M%)	(F%)	(K%)	Turret Perforations (Fighting Compt)	Hull Perforations: Fighting Compt	Drivers Compt	Engine Compt	Total Perforations
7	---	---	---	0	0	0	0	0
28	100	---	---	0	0	0	4	4
49	---	---	---	0	0	0	0	0
41	100	95	---	5	0	0	1	6
47	---	---	100	1	0	2	0	3
30	---	---	100	2	4	0	0	6
48	100	100	---	3	1	0	0	4
33	100	---	---	1	0	0	1	2
38	5	10	---	0	0	0	0	0
39	---	---	100	3	0	1	1	5
TOTALS:				15	5	3	7	30

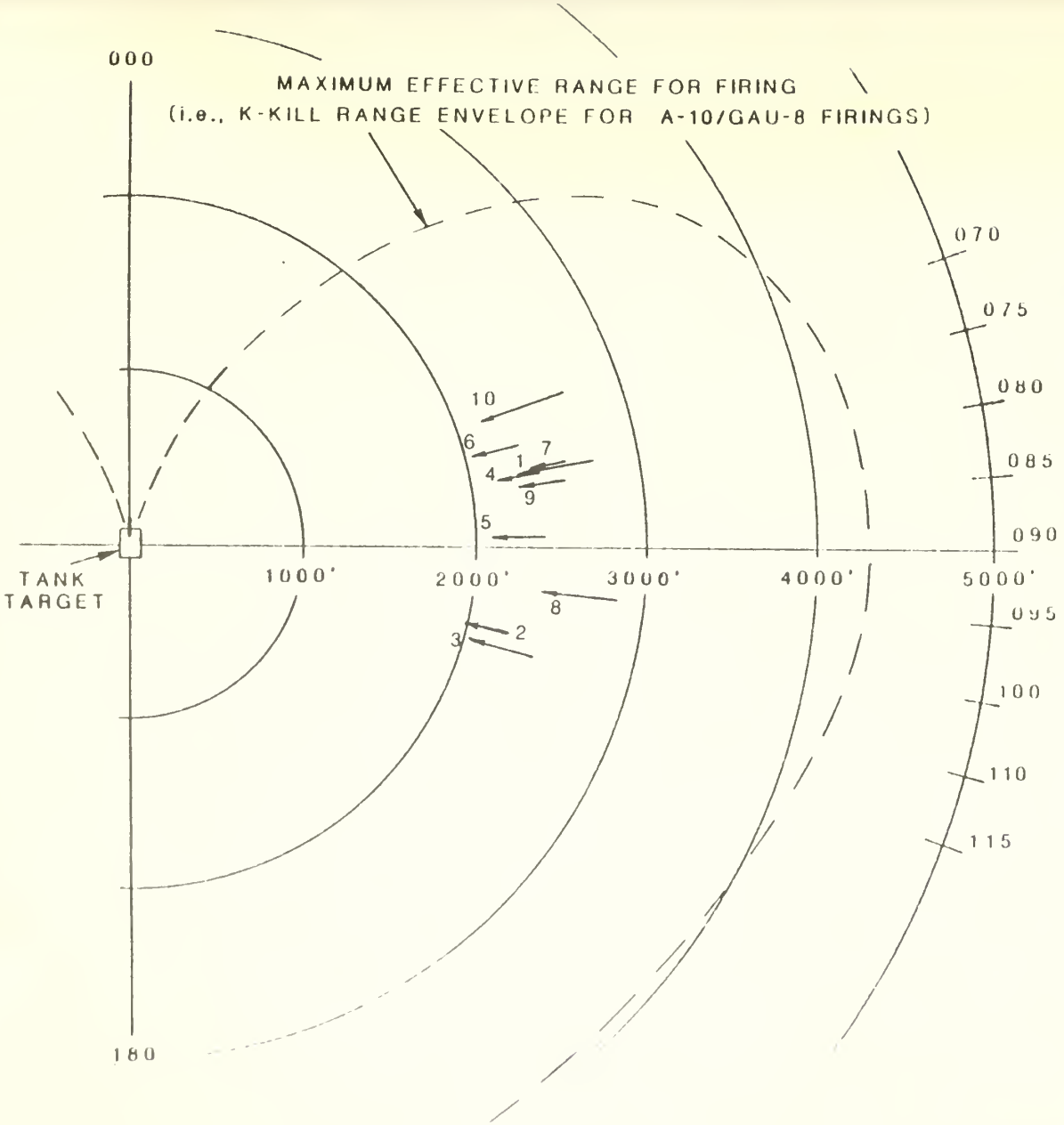
*K = Catastrophic Kill; M = Mobility Kill; F = Firepower Kill

TABLE A-III. Array 22 Aircraft Attack Parameters
(7 November 1980)

Acft Pass	Tank No.	Slant Range Open/Cease feet	Dive Angle Open/Cease degrees	Altitude feet	Velocity Open/Cease knots	Burst Length (Seconds)	Source
1/1	7	2699./2227	-3.0/-3.0	473.	579./581.	.81	HUD
1/2	28	2191./ *	-4.0/-3.0	438.	559./574.	.52	HUD
1/3	49	2334./2007.	-4.0/-4.0	463.	561./561.	.58	HUD
1/4	41	2406./2146.	-4.0/-4.0	453.	334./337.	.46	HUD
1/5	47	2334./2097.	-3.0/-3.0	413.	564./569.	.42	HUD
1/6	30	2263./2037.	-3.0/-3.0	393.	571./571.	.40	HUD
1/7	48	2547./2261.	-3.0/-5.0	393.	573./574.	.50	HUD
1/8	33	2758./2404.	-6.0/-6.0	583.	566./569.	.63	HUD
1/9	38	2547./2239.	-3.0/-3.0	413.	567./571.	.54	HUD
1/10	39	2618./2131.	-4.0/-4.0	463.	569./571.	.85	HUD

* Position uncertain.

Nominal HUD film Tolerances:
Slant Ranges: Plus zero minus 150. feet
Dive Angles : Plus .5 minus .5 degrees
Velocities : Plus 5 minus 5 knots
Burst times : Plus 0. minus .021 seconds



Pass #	Open Fire Range	Cease Fire Range	Relative Approach Angle
1	2699	2227	078
2	2191	*	105
3	2334	2007	110
4	2406	2146	078
5	2334	2097	088
6	2263	2037	075
7	2547	2261	078
8	2758	2404	097
9	2547	2239	082
10	2618	2131	070

* Position uncertain

FIGURE A-1. Mission 21 Attack Aspect Summary.

APPENDIX B

DEFINITIONS

The terms used in this report are defined below:

IMPACT -- Any evidence of a projectile strike against any portion of the target. Ground ricochets striking the target were classified as "impacts".

PERFORATION -- Any rupture of the armored envelope caused by an impacting projectile which results in a complete rupture of an armored surface by the projectile or spall fragments. A perforation can occur only when the armor is impacted. The word "Perforation" was deliberately selected to avoid the ambiquities which may occur through use of the word "penetration". Behind-the-plate effects may or may not result from a perforation.

HIT -- Any impact not classified as a perforation.

MOBILITY KILL (M-KILL) -- Loss of tactical mobility resulting from damage which cannot be repaired by the crew on the battlefield. A tank is considered to have sustained a 100% M-Kill when it is no longer capable of executing controlled movement on the battlefield. Mobility is DEGRADED when a tank can no longer maintain its position in the formation of which it is a part.

FIREPOWER KILL (F-KILL) -- Loss of tactical firepower resulting from damage which cannot be repaired by the crew on the battlefield. A tank is considered to have sustained a 100% F-Kill when it is incapable of delivering controlled fire from its main armament. Firepower is DEGRADED when a tank can no longer maintain its "normal" rate-of-fire, velocity, accuracy, time to shift targets, etc.

CATASTROPHIC KILL (K-KILL) -- A tank is considered to have sustained a K-Kill when both an M-Kill and a F-Kill have occurred as the result of killing fires and explosions from ignited fuel and/or ammunition. A tank which has suffered a K-Kill is considered not to be economically repairable, and, by U.S. standards, would be abandoned on the battlefield.

ATTACK ASPECT -- The angle of approach of the aircraft with respect to the orientation of the target with zero degrees representing the front of the tank (gun forward) and 180 degrees representing the rear of the tank.

SIGNIFICANT IMPACTS -- Impacts which damage systems, components or sub-systems resulting in their destruction or partial loss of function. This type damage contributes to the assessed kill.

INSIGNIFICANT IMPACTS -- Impacts which damage non-critical structural, convenience, or accessory components and which may result in their destruction or partial loss of function, but with no impact on mobility or firepower considerations. Good maintenance practices contemplates repair or replacement of such items at the earliest opportunity consistant with accomplishment of the mission.

DISTRIBUTION LIST FOR LAVP RESULTS

		No. Copies
1.	Mr. R.L. Saley Aerojet 1025 Connecticut Avenue, N.W. 12th Floor Washington, DC 20036	1
2.	Mr. Marshall Hoyler, Analyst Congressional Budget Office 2nd & D Streets, S.W. Washington, DC 20024	1
3.	Dr. John Barmby U.S. General Account Office 441 C Street N.W. Washington, DC 20548	1
4.	Lt. Col. Neal Edward Tash USAF/XOOTR Pentagon Washington, DC 20330	1
5.	Lt. Col. Donald E. Madonna BQ AFSC/XRLA Andrews AFB, MD Washington, DC 20331	1
6.	Col. John R. Boyd USAF, (ret.) OASD/PA&E, Room 2C 281 Pentagon Washington, DC 20301	1
7.	Dept. of the Air Force The Albert F. Simpson Historical Research Center/HOH Arthur W. McCants, Jr., Lt. Col. Chief, Oral History Branch Maxwell Air Force Base, Albama 36112	1
8.	354 TFW/DOW Myrtle Beach AFB, SC 29577	5
9.	81 TFW/CC RAF Bentwaters APO NY 09755	1

10.	81 TFW/DO RAF Bentwaters APO NY 09755	20
11.	23 TFW/DO England AFB, LA 71301	2
12.	USAF/TFWC/TE Nellis AFB, NV 89191	5
13.	Mr. Jerome H. Stolarow U.S. General Accounting Office 441 C Street, N.W. Washington, DC 20548	1
14.	MGEN Bernard E. Trainor Education Center MCDEC Quantico, VA 22134	1
15.	Maj O.W. McCormack Supporting Arms Instruction Division Education Center MCDEC Quantico, VA 22134	1
16.	Library (Attn: Reports Section) Naval Postgraduate School Monterey, CA 93940	1
17.	Mr. William Lind Office of Senator Gary Hart 254 Russel Building Washington, DC 20510	2
18.	Capt. Kenneth W. Estes USMC 102 Clemson Court Jacksonville, NC 28540	1
19.	Deupty Chief of Staff for Intelligence Headquarters Tactical Air Command Col. Herrmann Langley AFB, VA 23665	5
20.	Mr. James O. Carson Central Intelligence Agency/OSR Washington, DC 20505	1

21. Mr. Robert Korn — 1
Central Intelligence Agency
Washington, DC 20505

22. Mr. John Cuzzordo — 1
Central Intelligence Agency
Washington, DC 20505

23. Mr. Richard R. Hallock — 5
Intrac, Inc.
606 Wilshire Boulevard - Suite 400
Santa Monica, CA 90401

24. Mr. C.M. Gordon — 1
GE
777 14th, N.W.
Washington, DC 20005

25. Maj. M.R. Janay, USMC — 1
HQ DARCOM - Code DRCGS-F
5001 Eisenhower Avenue
Alexandria, VA 22304

26. Mr. Raymond R. McEachin — 5
P.O. Box 273
Hazlehurst, GA 31539

27. L.C. Hayes, USMC — 1
Headquarters, Marine Corps
Washington, DC 20380

28. K.R. Town, USMC — 1
Headquarters, U.S. Marine Corps
Washington, DC 20380

29. John C. McKay, USMC — 1
Headquarters, U.S. Marine Corps
Washington, DC 20380

30. Mr. Tyler W. Tandler — 1
1012 Deadrun Drive
McLean, VA 22101

31. Mr. E. Elko — 1
AOMC
9236 Rast Hall Road
Downey, CA 90241

32. Mr. K.H. Wolvington — 5
GE
Lakeside Avenue
Burlington, VT 05401

33. Mr. Kwai Chan — 1
U.S. General Accounting Office
441 C Street, N.W.
Washington, DC 20548

34. HQ TAC/DOOO — 2
Langley AFB, VA 23665

35. USAF Academy — 2
Library
USAF Academy, CO 80840

36. Herrn Dr. Horst Boog — 2
Wiss Oberrat
Militargeschichtliches Forschungsamt
7800 Freiburg im Breisgau
West Germany

37. Albert F. Simpson — 2
Historical Research Center
Attention: Mr. Fletcher
Maxwell AFB, AL 36112

38. CMDR Naval Air Systems Command — 1
Attention: PMA 235 B
Washington, DC 20361

39. DASD/ISA/ED — 1
Room 4D800
The Pentagon
Washington, DC 20301

40. Lt. Col. Howard J. Pierson — 10
139 Booker Street
Little Rock, AR 72204

41. USAF — 2
DCS/Plans & Operations Tactical Division
BF939B
The Pentagon
Washington, DC 20301

42. USAF — 2
DCS/Programs & Resources
Director of Programs Tactical Branch
4C152
The Pentagon
Washington, DC 20301

43. USAF — 2
DCS/Research & Development
Directorate of Operational Requirements
& Development Plans
Tactical Division
5E381
The Pentagon
Washington, DC 20301

44. HQ TAC/DO AT — 1
Langley AFB, VA 23665

45. HQ TAC/DO O — 5
Langley AFB, VA 23665

46. Mr. Andrew W. Marshall — 5
Director Not Assessment
Room 3A930
Pentagon
Washington, DC 20301

47. Dr. James A. Ross — 1
Institute for Defense Analyses
400 Army Navy Drive
Arlington, VA 22202

48. Lt. Col. Lanny T. Lancaster — 10
HDQ TAC/CCS
Langley AFB, VA 23665

49. Mr. Thomas E. Gaines — 1
P.O. Box 225907
Vought Corporation
Dallas, TX 75265

50. Mr. Emil H. Seaman — 1
Aerojet Ordnance Company
9236 East Hall Road
Downey, CA 90241

51. Mr. Charles E. Myers — 1
2000 S. Eads #113
Arlington, VA 22202

52. Mr. David G. Opheim — 1
Honeywell, Inc.
600 Second Street, N.E.
Hopkins, MN 55343

53. Mr. John D. Pafenberg — 1
HQ USAF/ING - Pentagon, Room 4A882
Washinton, DC 20330

54. Col. W.E. Barrineau, Jr. — 1
TFW/DO
APO NY 01923

55. HQ TAC/DOOF — 1
Langley AFB, VA 23665

56. HQ TAC/XP — 1
Langley AFB, VA 23665

57. USAF TFWC/SA — 1
Nellis AFB, NV 89191

58. 57 FWW/DO — 1
Nellis AFB, NV 89191

59. 12 AF/DO — 2
Bergstrom AFB, TX 78743

60. 9 AF/DO — 2
Shaw AFB, SC 29152

61. CINCUSAFE/DO — 1
Ramstein AFB
APO 09012

62. CINCUSAFE/DOOF — 2
Ramstein AFB
APO 09012

63. CINCUSAFE/DOOT — 2
Ramstein AFB
APO 09012

64. CINCUSAFE/DOST — 2
Ramstein AFB
APO 09012

65. USAF Maj. Gen. Kelly — 5
TFWC/CC
Nellis AFB, NV 89191

66. 66 FWC/CC — 50
Nellis AFB, NV 89191

67. Thomas P. Christie — 50
DASD (Tactical Air Program)
PA&E
Room 2E330
Pentagon
Washington, DC 20301

68. Maj. Davies (ASD/YXA) — 10
USAF/Aeronautical Systems Division
A-10 System Program Office
Directorate of Armament
Wright-Patterson AFB, OH 45433

69. Battele — 5
Columbus Laboratories
Tactical Technology Center
Room 13-4127
Attention: Mr. J. Tuck Brown
505 King Avenue
Columbus, OH 43201

70. HQ USAF — 5
DSC/RDF
Pentagon - 4D283
Washington, DC 20330

71. Lt. Gen. (USA Ret) H.R. Aaron — 1
7722 Kalorama Road
Annandale, VA 22003

72. Maj. Robert. K. Redlin — 1
Commandant of the Marine Corps
Code R&P
Headquarters, U.S. Marine Corps
Washington, DC 20380

73. Lt General P. X. Kelly, USMC — 1
Commander
Rapid Deployment Joint Task Force
MacDill AFB, FL 33608

74. Lt. Col. G. W. Keiser (Code RP) — 1
U.S. Marine Corps
Requirements & Programs
Washington, DC 20380

75. Mr. John F. Blake — 1
9312 Crown Place
Alexandria, VA 22308

76. Mr. Richard Eppard — 1
Central Intelligence Agency
Office of Logistics
Washington, DC 20505

77. Mr. Rudolf A. Endors — 1
10101 Colebrook Avenue
Potomac, MD 20854

78. Maj. Gen. Thomas P. Lynch — 1
Commanding General
U.S. Army Armor Center
Fort Knox, KY 40121

79. Lt. Col. John H. Ridge — 1
U.S. Army Armor Center
Fort Knox, KY 40121

80. Maj. Barry D. Watts — 1
OSD/Office of Net Assessment
Pentagon - 3A930
Washington, DC 20301

81. HQ TAC/CC — 2
Langley AFB, VA 23665

82. Library, Code 0212 — 2
Naval Postgraduate School
Monterey, CA 93940

83. Dept. Chairman — 2
Dept. of National Security Affairs
Naval Postgraduate School
Monterey, CA 93940

84. Professor R.H.S. Stolfi — 30
Dept. of National Security Affairs
Naval Postgraduate School
Monterey, CA 93940

85. AFIT/CIP (Library) — 2
Wright-Patterson AFB, OH 45433

86. AFIS/INH — 1
Ft. Belwoir, VA 22060

87. Brig. Gen. Reed — 5
355 TFW/CC
Davis Monthan AFB, AZ 85707

88. Col. Wayne E. Davis — 1
1411 Gemini Circle
Moody AFB
Valdosta, CA 31601

89. Brig. Gen. W.S. Harpe — 5
14 TFW
Columbus, MS 39701

90. 354 TFW/DCM — 1
Myrtle Beach AFB, SC 29577

91. TAC/DR — 1
Langley AFB, VA 23665

92. CIA/HQ — 2
Washington, DC 20505

93. General Elwood Quesada (Retd.) — 1
L'Enfanc Plaza
Washington, DC 20024

94. Mr. P.M. Sprey — 5
Box 264, R.D. 1
Glenn Dale, MD 20769

95. Mr. Mike Mecca — 2
Fairchild Industries
Germantown, MD 20767

96. Industrial College of the Armed Forces Library — 1
Ft. Lesley J. McNair
Washington, DC 20319

97. Mr. Bernard Kornhauser — 1
System Planning Corp.
1500 Wilson Blvd.
Suite 1500
Arlington, VA 22209

98. Maj. Gerald H. Felix, USAF — 5
112 TFG
Greater Pittsburgh Airport
Pennsylvania Air Guard
Pittsburgh, PA 15180

99. USMCDEC — 5
Firepower Division
Air Branch/Code D092
Attention: Ms. Kearns
Quantico, VA 22134

100. USAF TAWC — 1
Eglin AFB, FL 32542

101. Headquarters U.S. Marine Corps — 5
Chief of Staff
Arlington Annex
Room 2010
Columbia Pike & Arlington Ridge Road
Arlington, VA 20370

102. USAF Air University Library — 2
Maxwell AFB, AL 36112

103. CMDR, Naval Weapons Center — 2
Attention: Mr. Bates
China Lake, CA 93555

104. Col. Robert M. Gomez/DRXSR — 1
Deupty Director/Commanding Officer
Ballistic Research Laboratory
Building 328
Aberdeen Proving Ground, MD 21005

105. GE, Armament Systems Dept. — 1
Director
Lakeside Ave.
Burlington, VT 05401

106. HQ TAC/DO — 5
Langley AFB, VA 23665

107. 354 TFW/CC — 5
Myrtle Beach AFB, SC 29577

108. 23 TFW/CC — 1
England AFB, LA 71301

109. 356 TFS/DO — 5
Attention: Maj. Lt. Col. Jenny
Myrtle Beach AFB, SC 29577

110. USAC 4SC — 1
Ft. Leavenworth, KS 66027

111. 355 TFW/DOW 1
Davis Monthan AFB, AZ 85707

112. 355 TFW/DO(A-7) 5
Davis Monthan AFB, AZ 85707

113. 355 TFW/DO(A-10) 5
Davis Monthan AFB, AZ 85707

114. 333 TFTS/CC 1
Davis Monthan AFB, AZ 85707

115. 333 TFTS/DO 5
Davis Monthan AFB, AZ 85707

116. OLAC 4444 OPS SQ (ISD) 1
Davis Monthan AFB, AZ 85707

117. 355 TTS/CC 1
Davis Monthan AFB, AZ 85707

118. Herrn Dr. Stahl 2
Bundesarchiv-Militararchiv
78 Freiburg im Breisgau
Wiesentr 10
West Germany

119. Mr. Richard E. Tuck 1
U.S. General Accounting Office
441 C Street, N.W.
Washington, DC 20548

120. Col. Paul N. Chase 1
HQ USAF
AF/SAGP
Pentagon - 1D373
Washington, DC 20330

121. Mr. Peter McDavitt 1
Honeywell
600 Second Street, N.E.
Hopkins, MN 55343

122. Col. Carl Case 1
Fighter Division
Air Force Studies & Analysis
Pentagon - 1D380B
Washington, DC 20330

123. Lt. Col. John L. Welde
354 TFW/DO
MB AFB, SC 29577 — 1

124. Dr. Dieter H. Schwebs
U.S. General Accounting Office
441 C Street, N.W.
Room 6478
Washington, DC 20548 — 1

125. Col. Michael L. Wardinski
HQ Department of the Army
DAMI-RT
Pentagon - BF722
Washington, DC 20310 — 1

126. Mr. John Sloan
HQ Department of the Army
DAMI-RT
Pentagon - BF722
Washington, DC 20310 — 1

127. Mr. W.R. Beuch
HQ Department of the ARmy
DAMI-RT
Pentagon - BF722
Washington, DC 20310 — 1

128. FMC Corporation
1105 Coleman Avenue
Box 1201
Attention: Mr. Don Loughlin, MD510
San Jose, CA 95108 — 1

129. Lt. Col. J.W. Lent
HQ MC (Code RPR-7)
Washington, DC 20380 — 1

130. Edward Fuge (Major, Retired, USAF)
Department of Political Science
University of New Mexico
Albuquerque, New Mexico 87131 — 1

131. Mr. Arthur G. Hanley
Central Intelligence Agency
Procurement Management Staff
Washington, DC 20505 — 1

132. 50 TFW/CC
APO NY 09109 — 1

133. 50 TFW/DO
APO NY 09109 5

134. 50 TFW/DO 5
496 TFS
Attention: Maj. Ratley
APO NY 09109

135. Energy Efficiency System 1
Attention: Mr. Verdi
187 W. Orangethorpe Road
Suite P
Placentia, CA 92670

136. Col. Richard C. Head 1
Council on Foreign Relations
The Harold Pratt House
58 East 68 Street
New York, NY 10021

137. General Hermann Balck 1
7144 Asperg
Egerstr. 23
Federal Republic of Germany

138. Col. Faybanic 1
AWC/DAUM
Maxwell AFB, AL 36112

139. Mr. Cobleigh 1
Hughes Aircraft
Canoga Park, CA 91304

140. Boeing 1
Attention: Mr. Bud Nelson
P.O. Box 3999, M/S 40-30
Seattle, WA 98124

141. IDA 1
Attention: Dr. Whittemore
400 Army Navy Drive
Arlington, VA 22202

143. Lt. Gen. Mahlke 1
2350 Heikendorf
Steenkamp 8
Federal Republic of Germany

144. HQ USAF 1
Attention: Lt. Gen. John Pustay
Office of Chief of Staff
Pentagon
Washington, DC 20330

145. Studiengruppe Luftwaffe 1
Sicherung Akademie der Bundeswehr
2000 Hamburg 55
Manteuffelstr. 20
Federal Republic of Germany

146. Gen. Wilke 1
31 Alle
Schlepegrellstr. 30
Federal Republic of Germany

147. General F.W. von Mellenthin 1
Box 67759
Bryanston 2021
Johannesburg
Republic of South Africa

148. Herrn Brigadegeneral a.D. Paul-Werner Hozzel 1
Salierster. 4
D7500 Karlsruhe
Federal Republic of Germany

149. 91 TFS/CC/Dow 1
APO 09405
New York, New York 09012

150. 78 TFS/CC/DOW 1
APO 09405
New York, New York 09012

151. 92 TFS/CC/DOW 1
APO 09755
New York, New York 09012

152. Military Attache 1
U.S. Embassy (Rome, Italy)
APO 90794
New York, New York 09012

153. Millitary Attache 1
U.S. Embassy (Bonn, Federal Republic of Germany)
APO 09080
New York, New York 09012

154. Military Attache 1
U.S. Embassy (Saudi, Arabia)
APO 09697
New York, New York 09012

155. Military Attache 1
U.S. Embassy
Attention: Air Attache
New Delhi, India

156. Military Attache 1
U.S. Embassy
Attention: Maj. McBaron
Canberra, Austrialia

157. AFIS/INC 1
Attention: Col. Kuiper
Building 520
Bolling AFB, DC 20332

158. Mr. William Jenisch 1
Aerojet Ordance Manufacturing Company
9336 East Hall Road
Downey, CA 90241

159. USAFE/DOOW 1
Attention: Maj. Lindsey
APO New York, New York 09012

160. Mr. James Simon 1
Central Intelligence Agency
Washington, DC 20505

161. Mr. David Keener 1
Central Intelligence Agency
Washington, DC 20505

162. Mr. Aris Pappas 1
Central Intelligence Agency
Washington, DC 20505

163. Mr. Andrew Hamilton 1
Congressional Budget Office/NSIA
4th Floor HOB, Annex #2
U.S. Congress
Washington, DC 20515

164. Mr. Pat Hillier 1
Congressional Budget Office/NSIA
4th Floor HOB, Annex #2
U.S. Congress

Washington, DC 20515

165. Dr. Dov Zakheim 1
Congressional Budget Office/NSIA
4th Floor HOB, Annex #2
Washington, DC 20515

166. Mr. John Hamre 1
Congressional Budget Office/NSIA
4th Floor HOB, Annex #2
U.S. Congress
Washington, DC 20515

167. Ms. Grace P. Hayes 1
T.K. Dupuy Associates, Inc.
P.O. Box 157
Dunn Loring, VA 22027

168. Mr. C. Curtiss Johnson 1
T.N. Dupuy Associates, Inc.
P.O. Box 157
Dunn Loring, VA 22027

169. Ms. Lucille Patterson 1
T.N. Dupuy Associates, Inc.
P.O. Box 157
Dunn Loring, VA 22027

170. Col. A.J. Kettering 1
OSD/OUSDR&E
Pentagon
Washington, DC 20301

171. Mr. Robert S. Dotson 1
Senate Armed Services Committee
212 Russell Senate Office Building
Washington, DC 20510

172. Mr. Steven Canby 1
10871 Springknoll Drive
Potomac, MD 20854

173. Director 1
U.S. Army Aberdeen Research & Development Center
Army Materiel Systems Analysis Activity/DRXSY
Aberdeen Proving Ground, MD 21005

174. Mr. Michael W. Iten/DRXSY-C 1
U.S. Army Materiel Systems Analysis Activity
Aberdeen Proving Ground, MD 21005

175. Mr. G.A. Zoller 1
U.S. Army Materiel Systems Analysis Activity/DRXSY
Aberdeen Proving Ground, MD 21005

176. Maj. J.F. Balda 1
U.S. Army Materiel Systems Analysis Activity/DRXSY
Aberdeen Proving Ground, MD 21005

177. Mr Arif R. Zaky 1
U.S. Army Materiel Systems Analysis Activity/DRXSY
Aberdeen Proving Ground, MD 21005

178. Mr. Arthur W. Garrett 1
U.S. Army Materiel Systems Analysis Activity/DRXSY
Aberdeen Proving Ground, MD 21005

179. Mr. T.A. Romanko 1
U.S. Army Material Systems Analysis Activity/DRXSY
Aberdeen Proving Ground, MD 21005

180. Mr. Stanley Eibertz 1
U.S. General Accounting Office
441 C Street, N.W.
Washington, DC 20548

181. Mr. Fredic S. Feer 1
Analytical Assessments Coorporation
P.O. Box 9102
Arlington, VA 22209

182. Mr. Dan Costello 1
OMB
New Executive Office Building
R10026
Washington, DC 20503

183. Mr. Gordon P. Lynch 1
Boeing Aerospace Company
Box 3999 - M/S 47-63
Seattle, WA 98124

184. Lt. Col. George W. Burkley 1
1875 Temple Hills Drive
Laguna Beach, CA 96215

185. Mr. Gerald Mayefskie 1
Quest Research Corporation
6845 Elm Street
McLean, VA 22101

186. Dr. John E. Tashjean 1
BDM
7915 Jones Branch Drive
McLean, VA 22101

187. Mr. David A. Brinkman 1
U.S. General Accounting Office
441 C Street, N.W. - Room 6478
Washington, DC 20548

188. Mr. Wayne H. Coloney 1
P.O. Box 5258
Tallahassee, FL 32301

189. Lt. Gen. M.P. Casey, USAF (ret.) 5
Wayne H. Coloney Company
P.O. Box 5258
Tallahassee, FL 32301

190. Mr. Richard W. Oates 5
General Electric
Lakeside Avenue
Burlington, VT 05401

191. Lt. Col. James Cord 1
Command and Staff College
Marine Corps Development & Education Command
Quantico, VA 22314

192. Brig. General W.H. Fitch 1
Deputy Chief of Staff, R&D and Studies
USMC
Arlington Annex
Washington, DC 20380

193. Mr. Jim Erickson 1
Grumman Aerospace
BOS-05
Bethpage, NY 11714

194. Professor Andrew Cyorgy 1
Sino-Soviet Institute
George Washington University
2029 G Street, N.W.
Washington, DC 20052

195. Mr. Charles Bernard 1
Director, Land Warfare
OSD/OUSDRE
Pentagon
Washington, DC 20301

196. 162 TFG/FWS 10
P.O. Box 11037
Tucson, AZ 85734
Attention: Lt. Col. O'Donnell

197. Mr. P. Nichols 1
Ayres Corp.
P.O. Box 3090
Albany, GA 31706

198. Herrn Brigadegeneral a.D Loytved-Hardegg 1
41 Odenbergerstr.
5800 Nurnberg
Federal Republic of Germany

199. Herrn Oberst a.D. Poetter 1
21-2 Alter Remise
8941 Kronburg
Federal Republic of Germany

200. Dr. Richard Staar 1
Dir. International Studies Pgms.
Hoover Institute
Stanford, CA 94305

201. Armament Systems, Inc. 1
712-F North Valley Street
Anaheim, CA 92801
Attention: Mr. Tom Gilbert

202. Defense Technical Information Center 2
(DTIC)
Cameron Station
Alexandria Virginia, 22314

203. Dean of Research 1
Naval Postgraduate School
Monterey, CA 93940

U195614

DUDLEY KNOX LIBRARY - RESEARCH REPORTS
5 6853 01068248 7
U19561